GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ____

Project No. A-3884 — GTRI/~~GTRC~~ — DATE 7 /20 /84

Project Director: C. P. Burns — ~~School~~/Lab STL/CC

Sponsor: CHEMFAB Birdair Structures, Inc. Buffalo, NY 14225

Type Agreement: P.O. 55352

Award Period: From 6/14/84 To 9/30/84 (Performance) --- (Reports)

Sponsor Amount:	This Change	Total to Date
Estimated:	$ 5,046	$ 5,046
Funded:	$ 5,046	$ 5,046

Cost Sharing Amount: $ n/a — Cost Sharing No: ____

Title: Radome Test Program

ADMINISTRATIVE DATA

OCA Contact William F. Brown x4820

1) Sponsor Technical Contact:

Milton B. Punnett, Chief Engineer
CHEMFAB, Birdair Structures Division
2015 Walden Ave.
Buffalo, NY 14225

(716) 684-9500

2) Sponsor Admin/Contractual Matters:

Robert D. Pritchard
Purchasing Manager
Birdair Structures, Inc.
2015 Walden Ave.
Buffalo, NY 14225
716/684-9500

Defense Priority Rating: n/a — Military Security Classification: n/a

(or) Company/Industrial Proprietary: n/a

RESTRICTIONS

See Attached --- Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with none proposed.

COMMENTS:

Sponsor I.D. #01.202.000.84.012

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GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 11/28/84

Project No. A-3884 ~~School~~/Lab STL

Includes Subproject No.(s)

Project Director(s) C. P. Burns GTRI / ~~GIT~~

Sponsor Chemfab Birdair Sturctures, Inc. Buffalo, NY 14225

Title Radome Test Program

Effective Completion Date: 9/30/84 (Performance) 9/30/84 (Reports)

Grant/Contract Closeout Actions Remaining:

NOTE: No Deliverable Schedule

- [ ] None
- [X] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. Continued by Project No.

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Other A. Jones; M. Heyser

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
Atlanta, Georgia 30332

29 October 1984

Milton B. Punnett
Chemfab, Birdair Structures Division
2015 Walden Avenue
Buffalo, N. Y. 14225

SUBJECT: Birdair Radome Seam Study
(Panel RF Test)
PO55352, ST-MS-1438, A-3884

Gentlemen:

Enclosed is the final report package for the Geoshell radome seam study. Included are the original amplitude and phase plots as requested. Further study and tests are possibly needed to suitably characterize each joint in terms of near-field insertion loss and phase delay. If further study is justified, we will be glad to assist in the endeavor.

Respectfully submitted,

[redacted]

Royce J. Byrd

BIRDAIR RADOME SEAM STUDY

PROJECT NUMBER A-3884

FINAL REPORT PACKAGE PHASE I

PACKAGE INCLUDES:

COVER LETTER
SUMMARY BRIEF
DONALD G. BODNAR'S REPORT
ORIGINAL DATA
REDUCED DATA

FOR:

MILTON B. PUNNETT
CHEMFAB, BIRDAIR STRUCTURES DIVISION
2015 WALDEN AVENUE
BUFFALO, N.Y. 14225

BY:

ROYCE J. BYRD
MICROWAVE SYSTEMS DIVISION
SYSTEMS AND TECHNIQUES LABORATORY
GEORGIA TECH RESEARCH INSTITUTE
ATLANTA, GA 30332

OCTOBER 1984

Birdair Radome Seam Study
Project Number A-3884
Royce J. Byrd
Summary Brief

Near-field measurements were conducted August 28-30, 1984 to determine the individual phase and amplitude effects for six different seams (junctions) in GEOSHELL radome material. These measurements were conducted by Milton B. Punnet and Mike Sinofsky of Birdair.

The near-field range was equipped and configured as shown in Figure 1. The range was initially tuned at 2.6 GHz for minimum roll-off of phase and amplitude in free space by adjusting the distance along boresight between the dish and the probe, and by carefully placing absorber under the upper half of the dish and around the panel mounting stand. This assured as close of an approximation to a plane wave as conditions would permit. A data set was then taken consisting of an amplitude and phase plot of free space followed by an amplitude and phase plot of a panel. A plain panel was tested first and looked as expected with little or no difference in amplitude and phase variation, except for the phase delay of the radome material itself. After trying several panels, it was discovered that the panel was too far away from the probe. It was then moved to within a wavelength of the probe for normal incidence (non-normal incidences resulted in greater than one wavelength distances).

A data set was then taken for the plain panel and all six junctions with a free space reference for each. This included polarizations both parallel and vertical to the seam. Incident angles were included for the more rigid panels. The data obtained was then reduced in the following manner. For each seam, panel data was subtracted from corresponding free space data, point by point (resolution = .626" of probe movement vertical) for both phase and amplitude respectively. This data was then re-plotted using the same scale. These plots were to be traced by an HP 7221A plotter, sending the collected data to a MV 4000 Data General computer file for program analysis. Due to budget constraints, only two panel seams and the

main panel were analyzed in this manner. The best and worst case panels, IIA and IIIA respectively, were chosen.

Analysis of the data was conducted by Donald G. Bodnar and his report follows this summary. Included in this entire report package is a table (Table I) whose numbers were derived by taking the average of the maximums and minimums within the corresponding two-foot window of the reduced data.

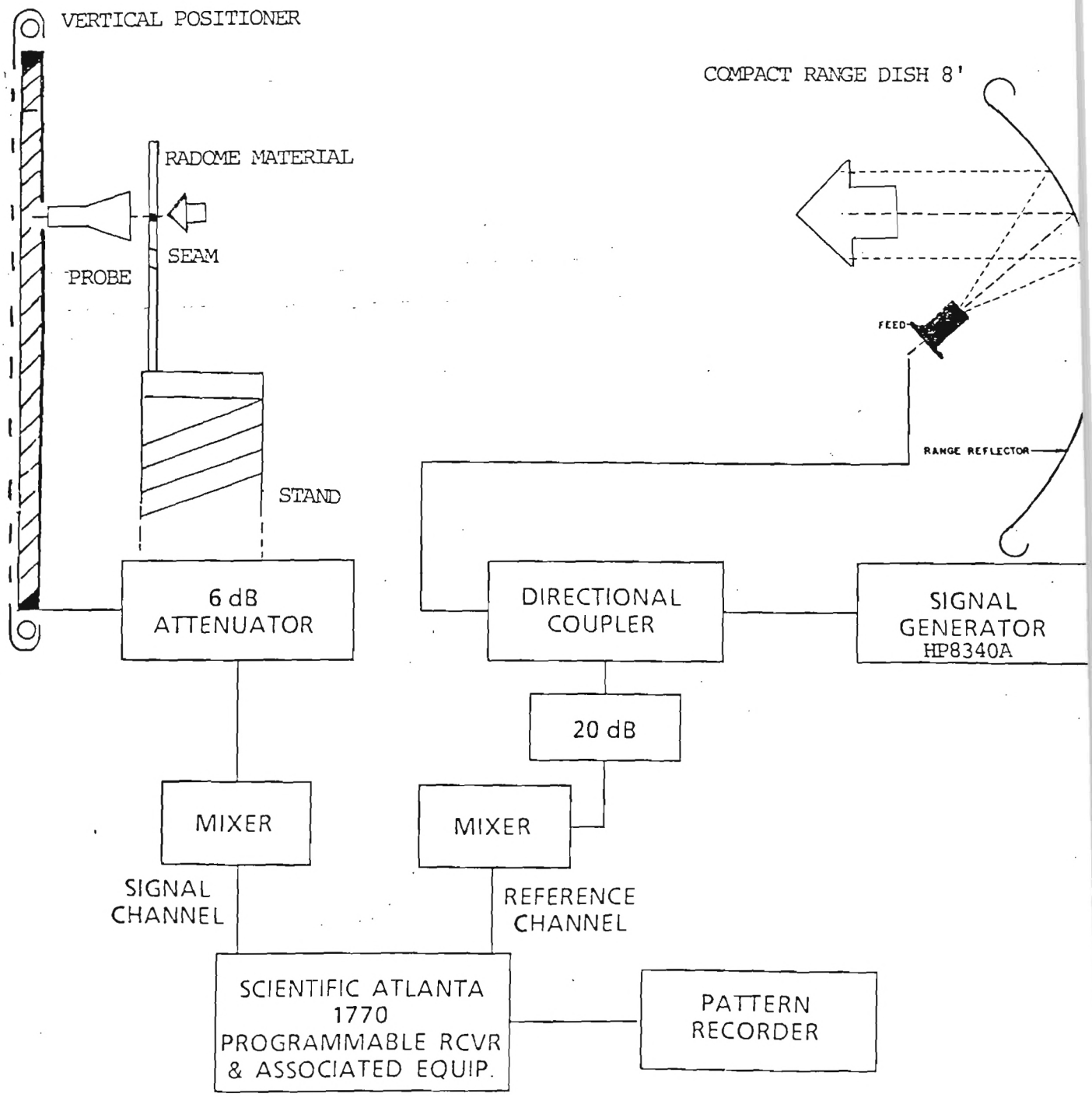


FIGURE 1. NEAR-FIELD RANGE TEST SETUP (CW)

Table I
Averages of Composite Amplitude & Phase

	Vertical Polarization		Horizontal Polarization	
Panel	Amplitude dB	Phase°	Amplitude dB	Phase°
I	-.09	-13	-.05	-13
II A	-.76	-22.5	-.7	-23
III A	-1.55	-24.5	-8.4	-33.5

ANALYSIS OF MEASURED SEAM DATA

By: Donald G. Bodnar

Measurements were made of the panel junctions with a horn that was placed about one wavelength away from the panel. Phase and amplitude data were recorded as the horn was moved past the junction. It was hoped that this data would give junction characteristics directly. However, the horn averaged information from either side of the junction itself making it difficult to use the measured data directly.

A first step at removing the averaging by the horn was attempted. The measured data was corrected to remove the effects of the horn by using an approximate model of the horn and the measurement geometry. The horn effects were removed from the data and the data was then transformed to the surface of the panel. Figures A-1 through A-4 show the results of these calculations for panels IIA and IIIA. The horizontal polarized measurements show a dip in amplitude and phase as the horn passed the junction which is expected. The vertically polarized cuts, however, showed an increase in amplitude at the center of the junction, which is not expected. It appears that part of the model is working but there is still more work to be done to get all of the model working.

It is recommended that further analysis be performed to refine the above technique for correcting the measured data, and that further measurement be made to validate the technique.

Note, for figures A-1 through B-2, a major horizontal division represents 2.625 inches of travel of the vertical positioner, and a major vertical division represents either 1dB in amplitude or 20 degrees in phase. The dotted curves in these figures represent phase and the solid curves represent amplitude.

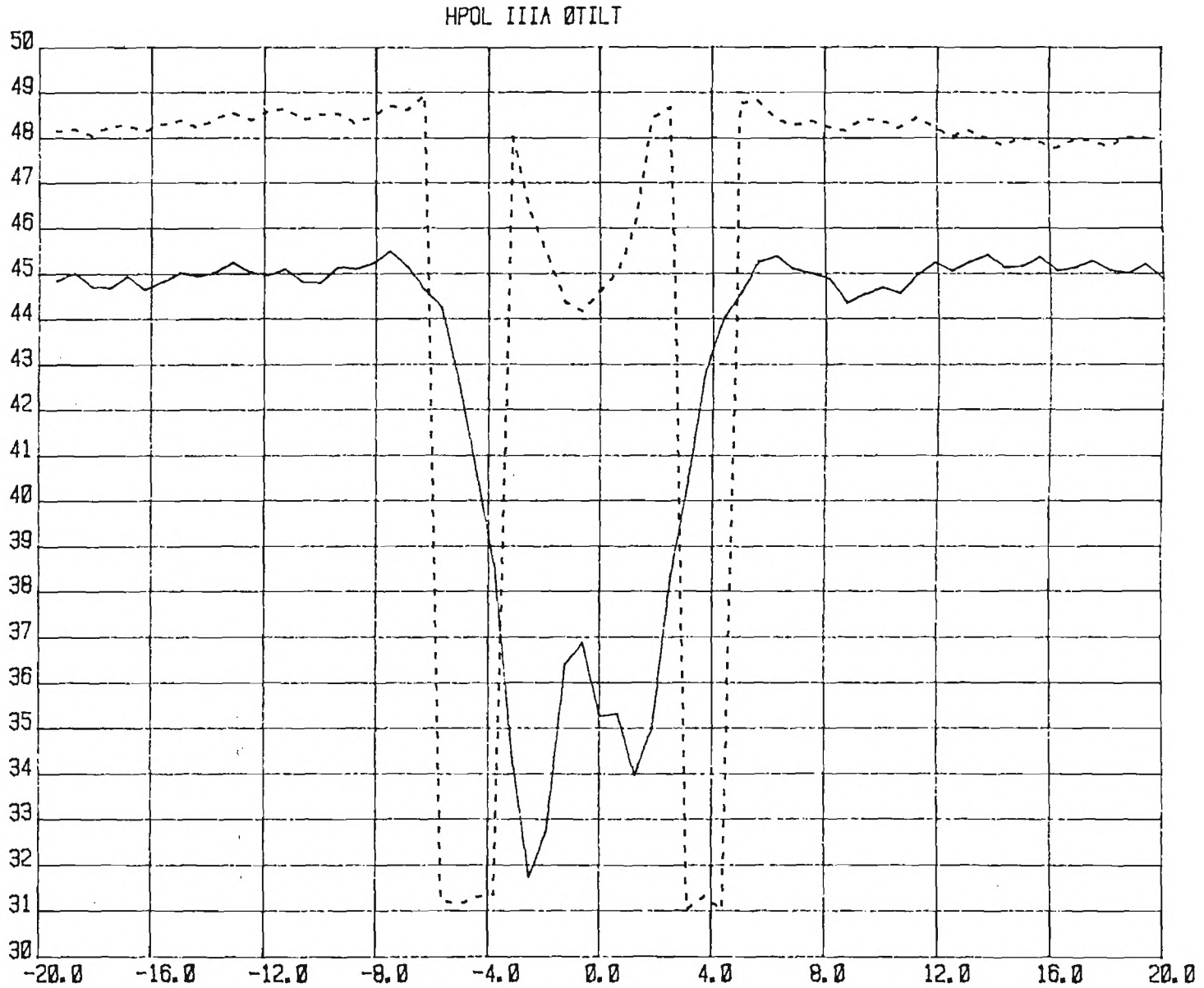
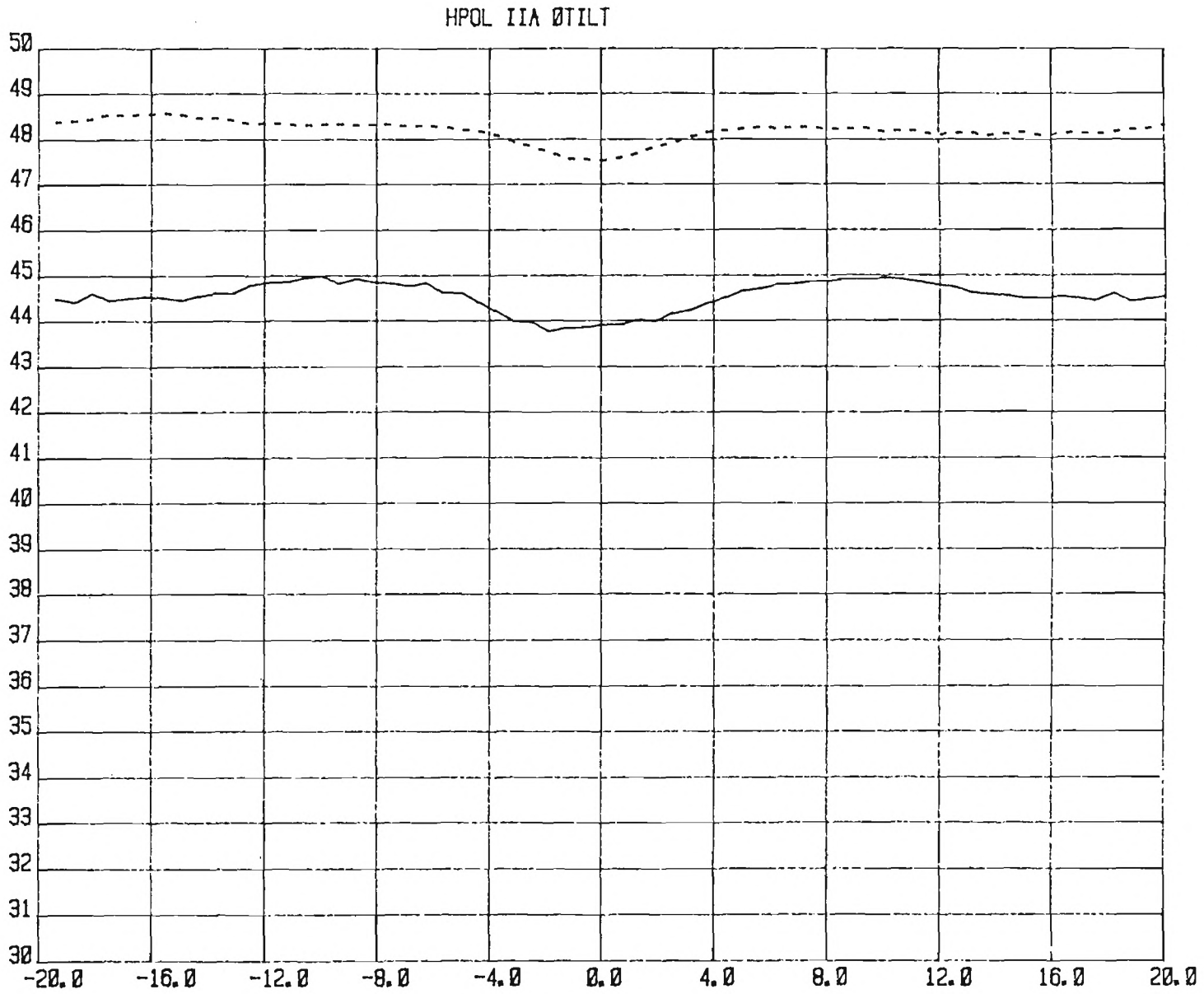


Figure A-1, Panel IIIA, Horizontal Polarization, No tilt.



Fiqure A-2, Panel IIA, Horizontal Polarization, No tilt.

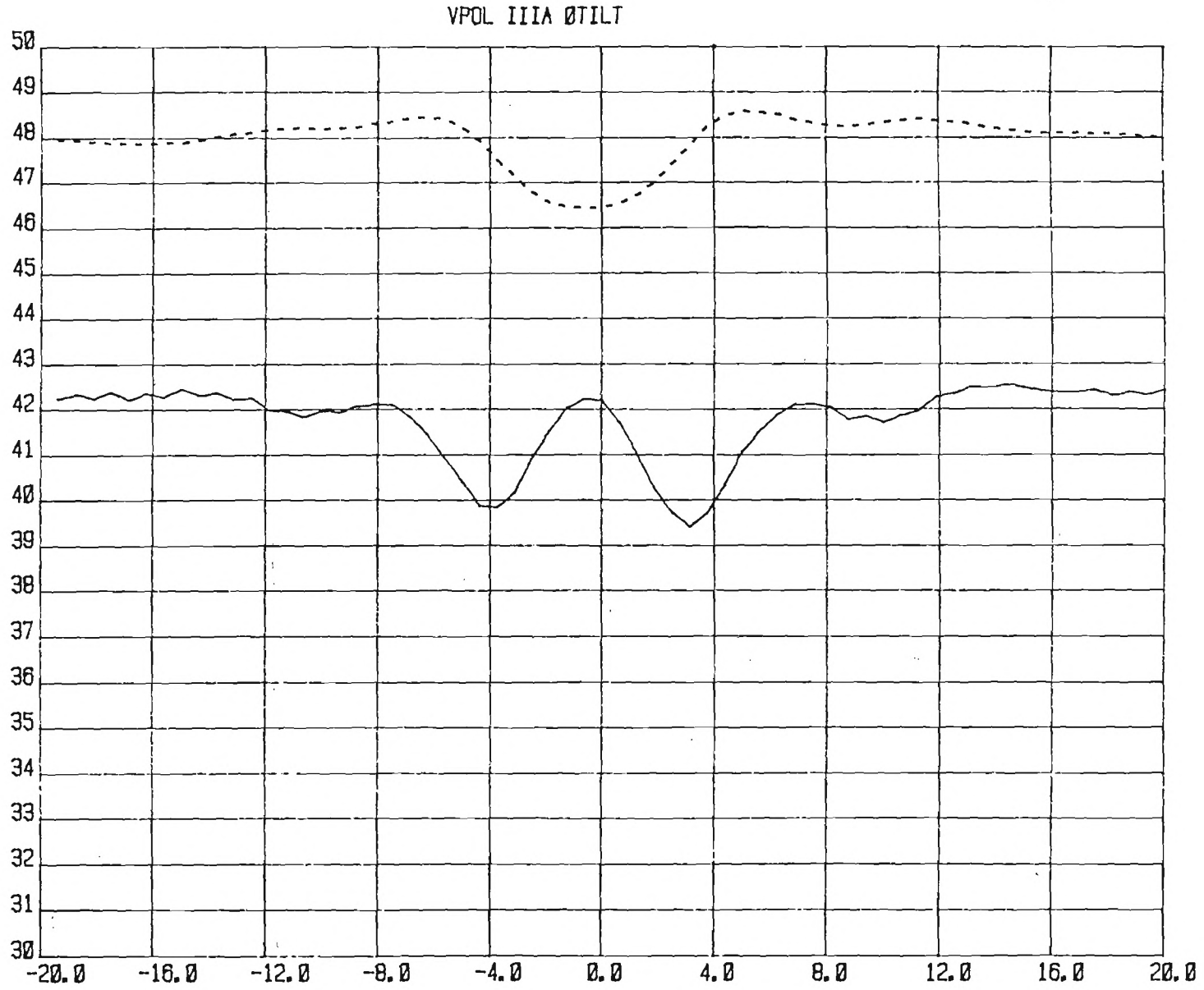


Figure A-3, Panel IIIA, Vertical Polarization, No tilt.

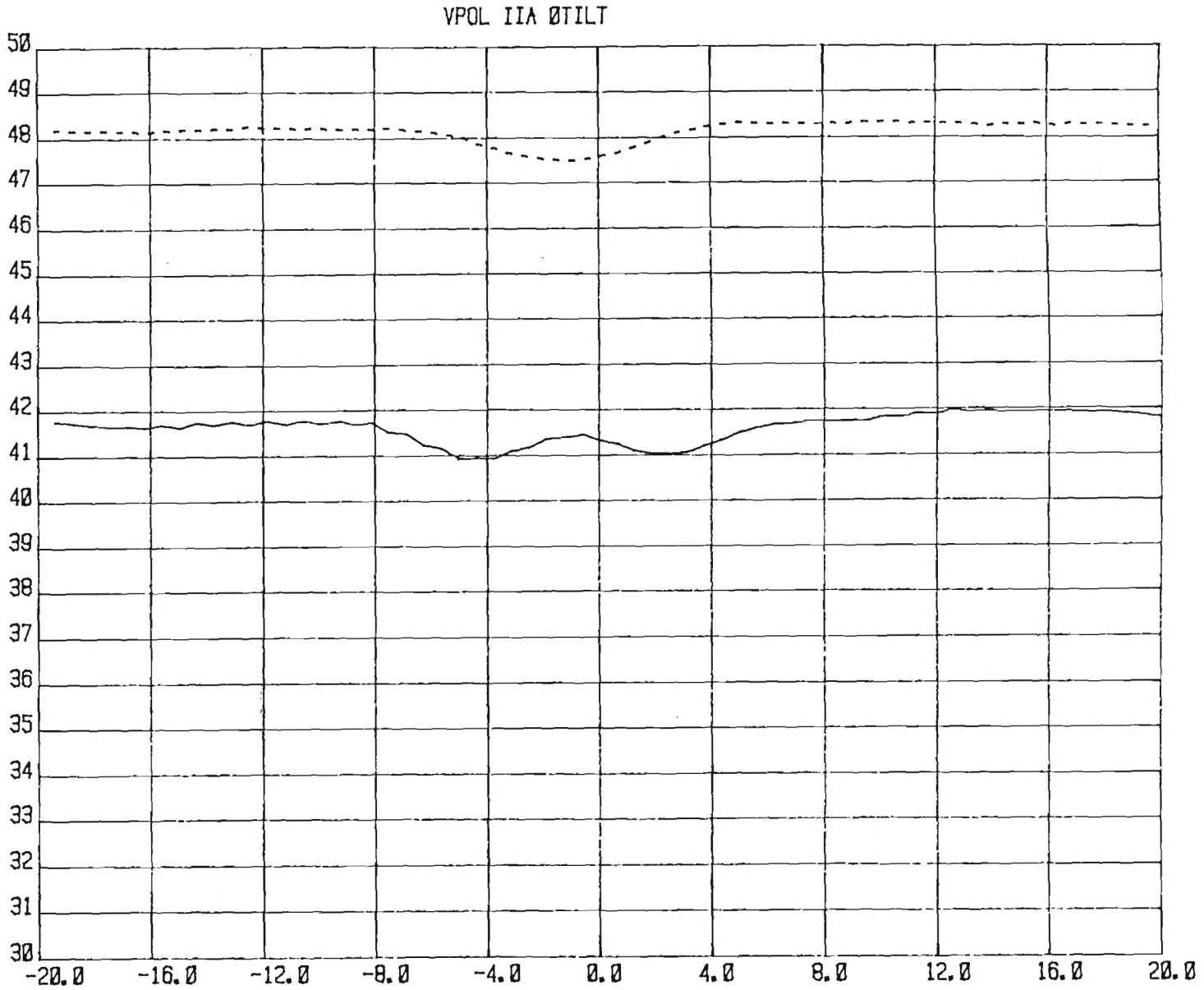


Figure A-4, Panel IIA, Vertical Polarization, No tilt.

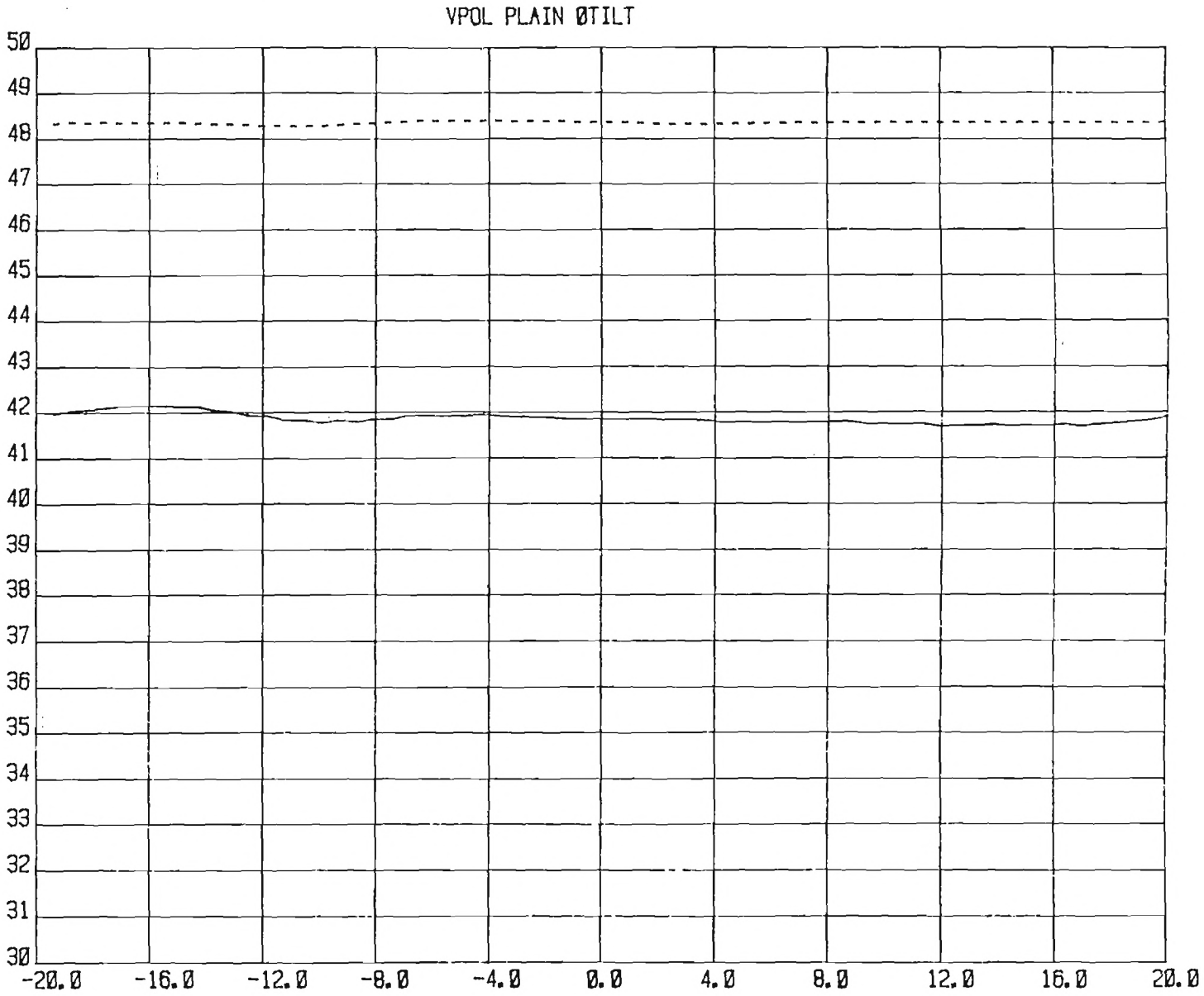


Figure B-1, Plain Panel I, Vertical Polarization, No tilt.

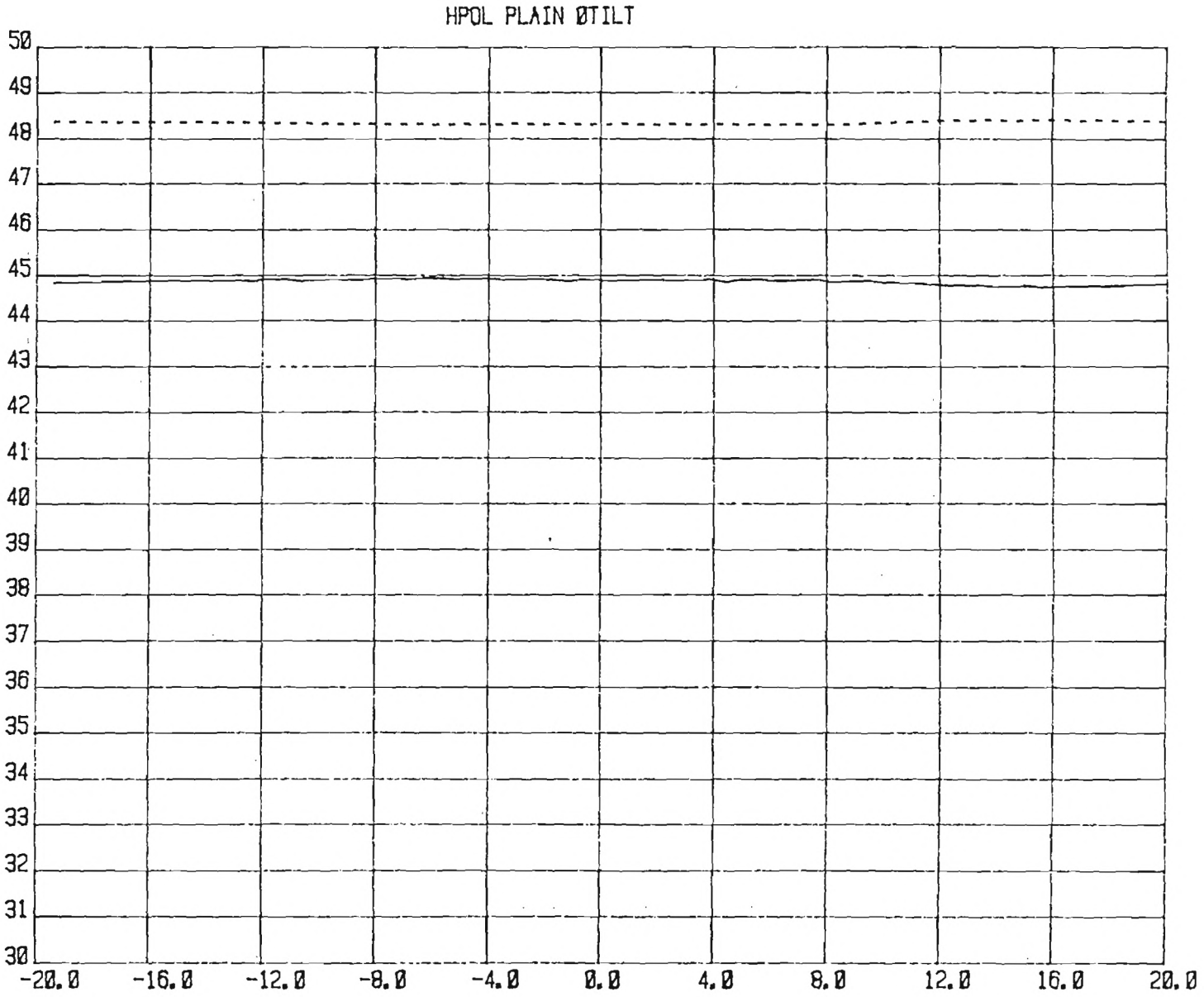


Figure B-2, Plain Panel I, Horizontal Polarization, No tilt

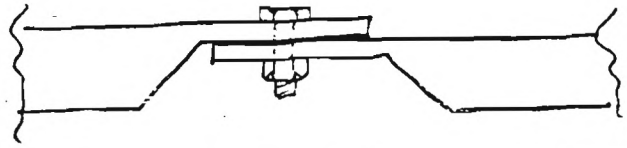
BIRDAIR/CHEMFAB RADOME PANEL JOINTS
GEOSHELL FOR RF TESTS
PROJ. # 8151

Ref: Mill Pond
Birdair

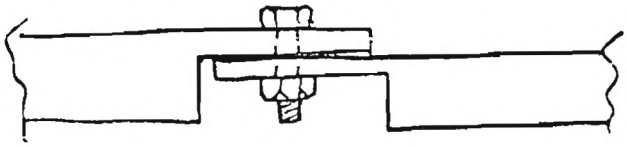
(I) Plain Panel 48"x48" - two joint

(II) Lap Joint Panels with removeable "Tuner Strips"

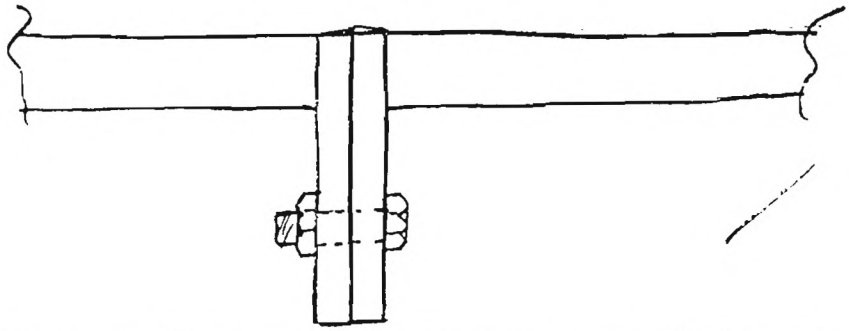
A)



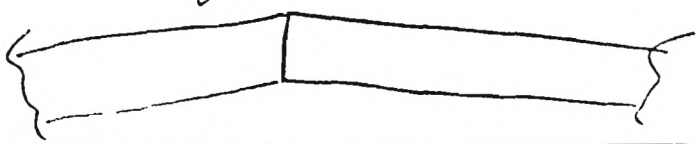
B)



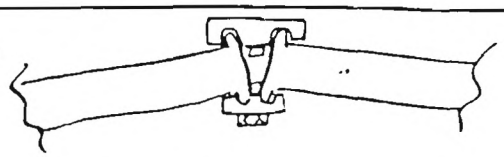
(III) A) Face Flange Joint:



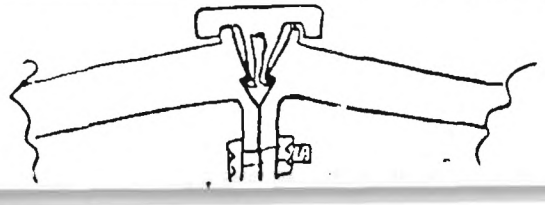
(III) B) Angular Butt Joint in Plain Panels:



(IV) A) Twin Channel Joint: with multiple tuner strips that can be added

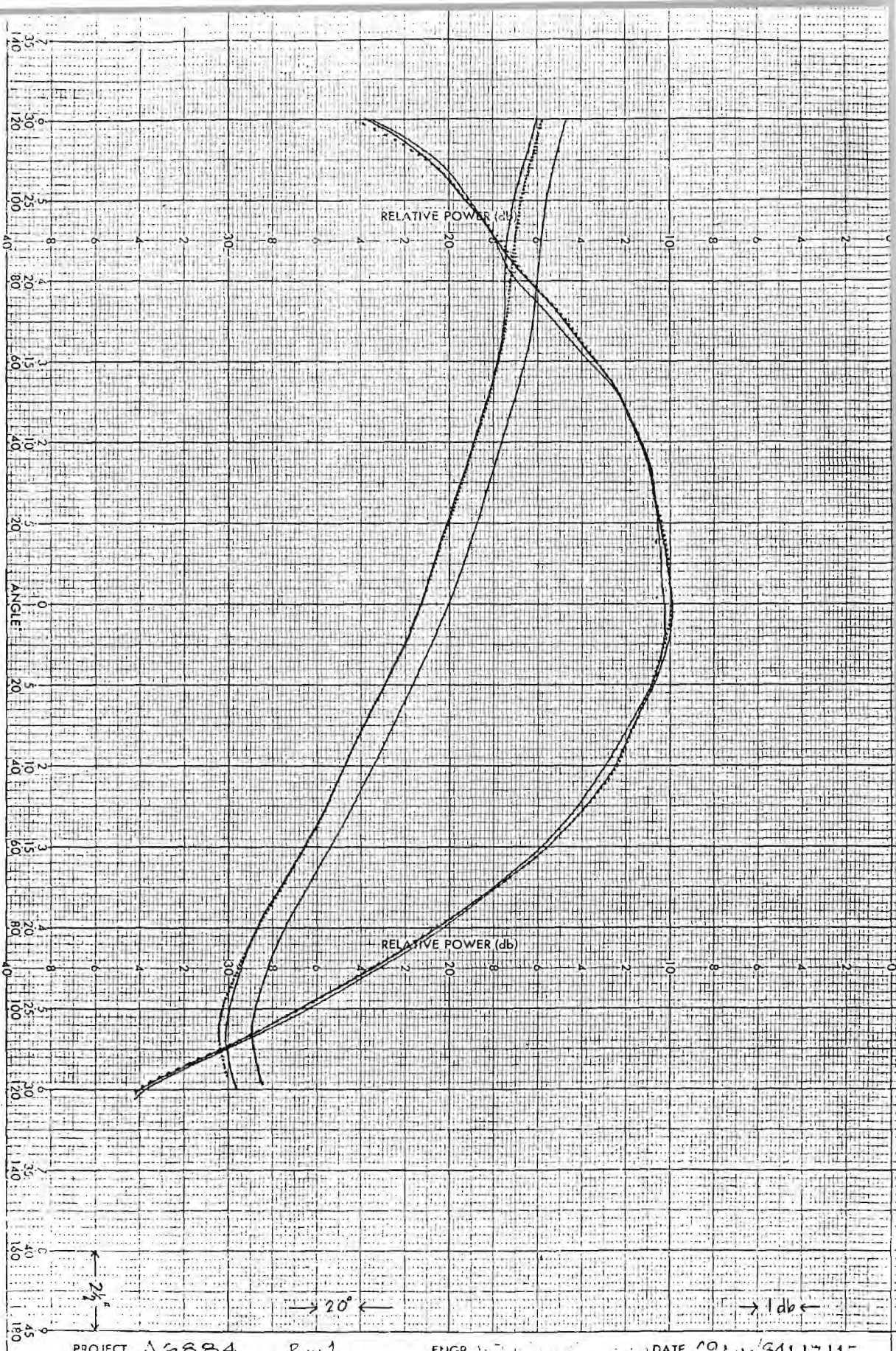


(IV) B) Channel-Flange Joint:



NEAR FIELD RANGE

AMPLITUDE AND PHASE PLOTS

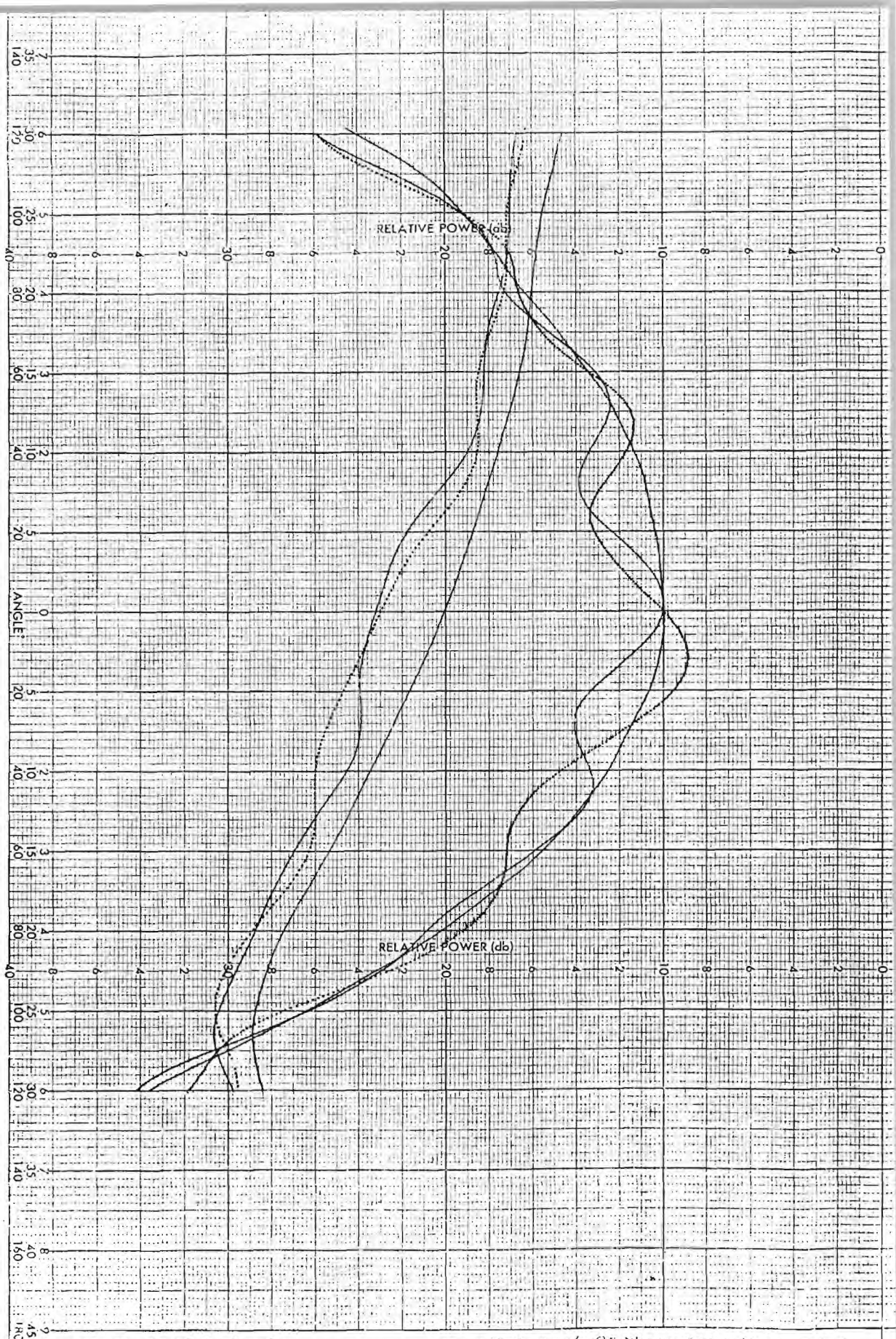


PROJECT A5884 RUN 1 ENGR [illegible] DATE 29 AUG 84147415

REMARKS F = 2.6 GHz
VERTICAL POLARIZATION
PLAIN PANEL

PROBE R HORN TO PANEL JOINT DISTANCE = 2.5" NORMAL
DISH TO PANEL DISTANCE = 160"
HORN SIZE $2\frac{13}{16} \times 2\frac{9}{16}$
WAVE GUIDE SIZE WR284

BLUE = FREE SPACE
Green = Panel II Plain - Normal Inc.
Dotted Green = " " 20° Incident



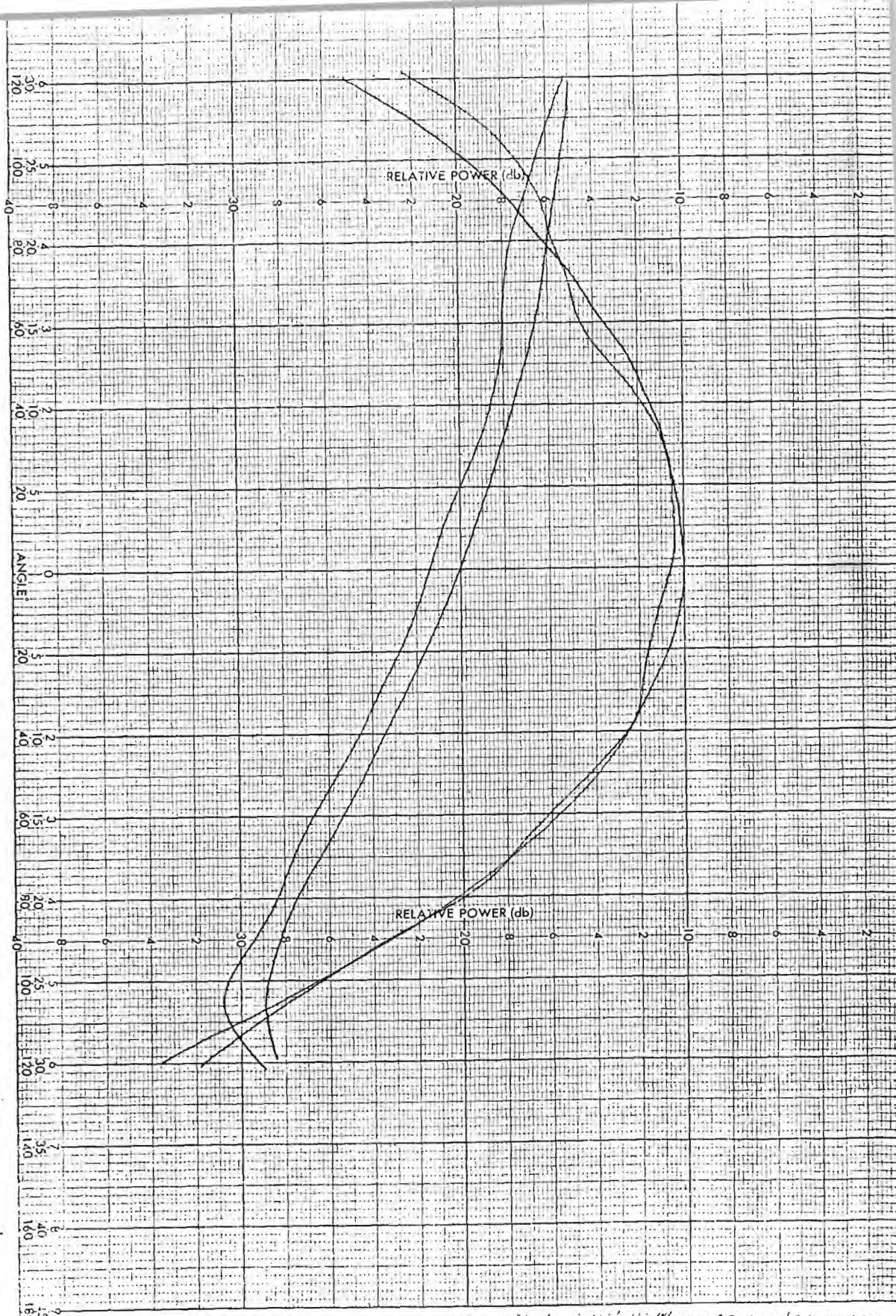
PROJECT 43834 RUN 2 ENGR [illegible] DATE 9/26/84 147416

REMARKS F = 2.6 GHz

VERTICAL POLARIZATION ⊥ TO JOINT PANEL II A (LAP JOINT)

PROBE HORN TO PANEL JOINT DIST. = 3.5"
JOINT ~@0

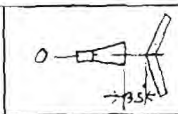
BLUE = FREE SPACE
GREEN = NORMAL INCIDENCE PANEL II LAP JOINT A
DOTTED GREEN = 15° INCIDENCE ↗



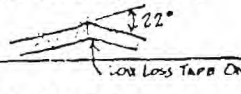
PROJECT A3884 RUN 3
REMARKS F = 2.6 GHz
VERTICAL POLARIZATION ⊥ TO JOINT

ENGR [illegible] DATE 29 AUG '84 17:17
2:20 PM

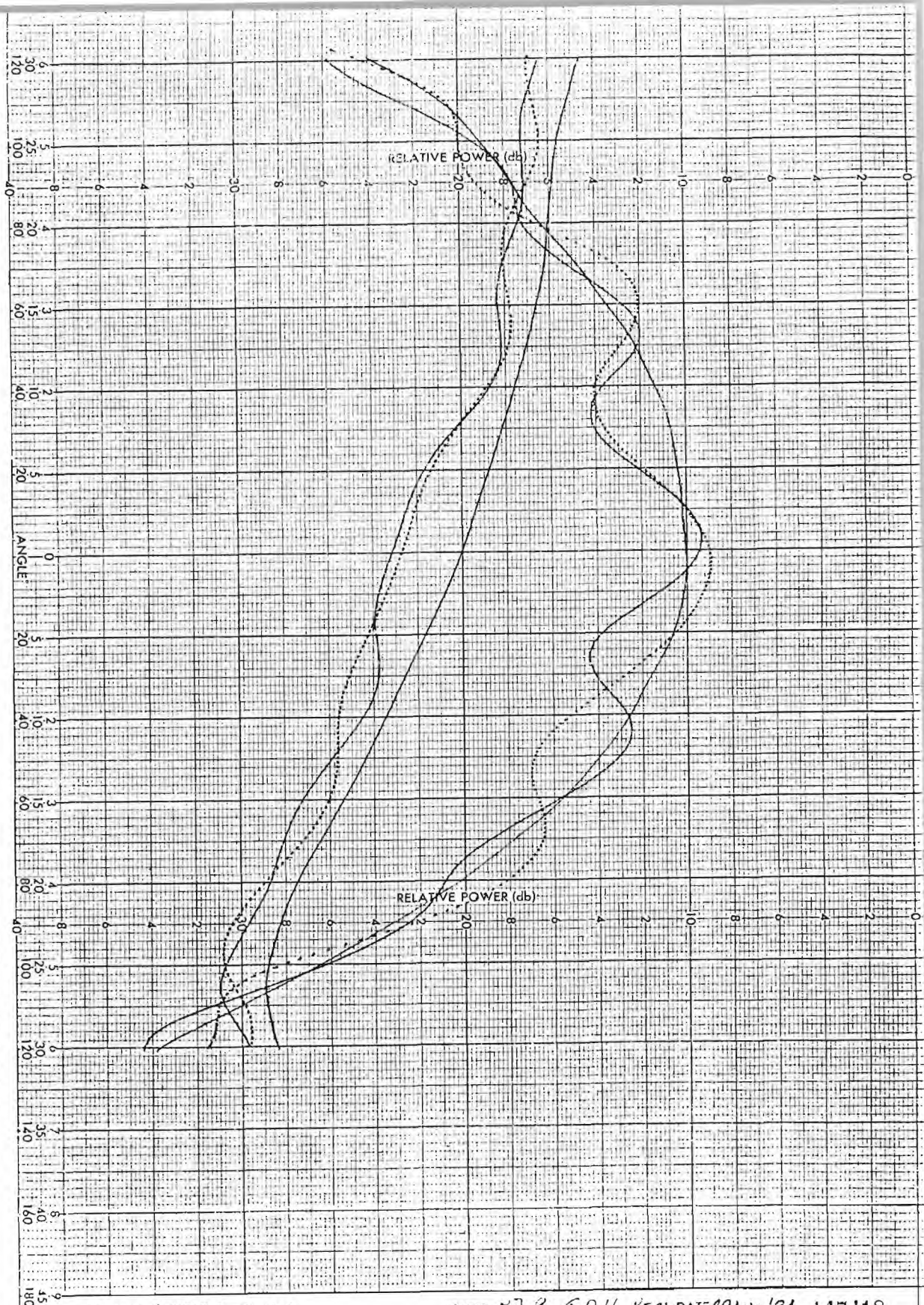
PANEL III B ANGULAR BUTT JOINT



W/ PLAIN PANEL
(NO JOINING PCS.)



BLUE = FREE SPACE
GREEN = PANEL III B @ NORMAL INCIDENCE



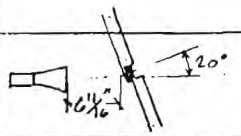
PROJECT A3884 RUN 4 ENGR NJ B, GDH, VTAI DATE 29AUG'84 14741S
2:40 PM

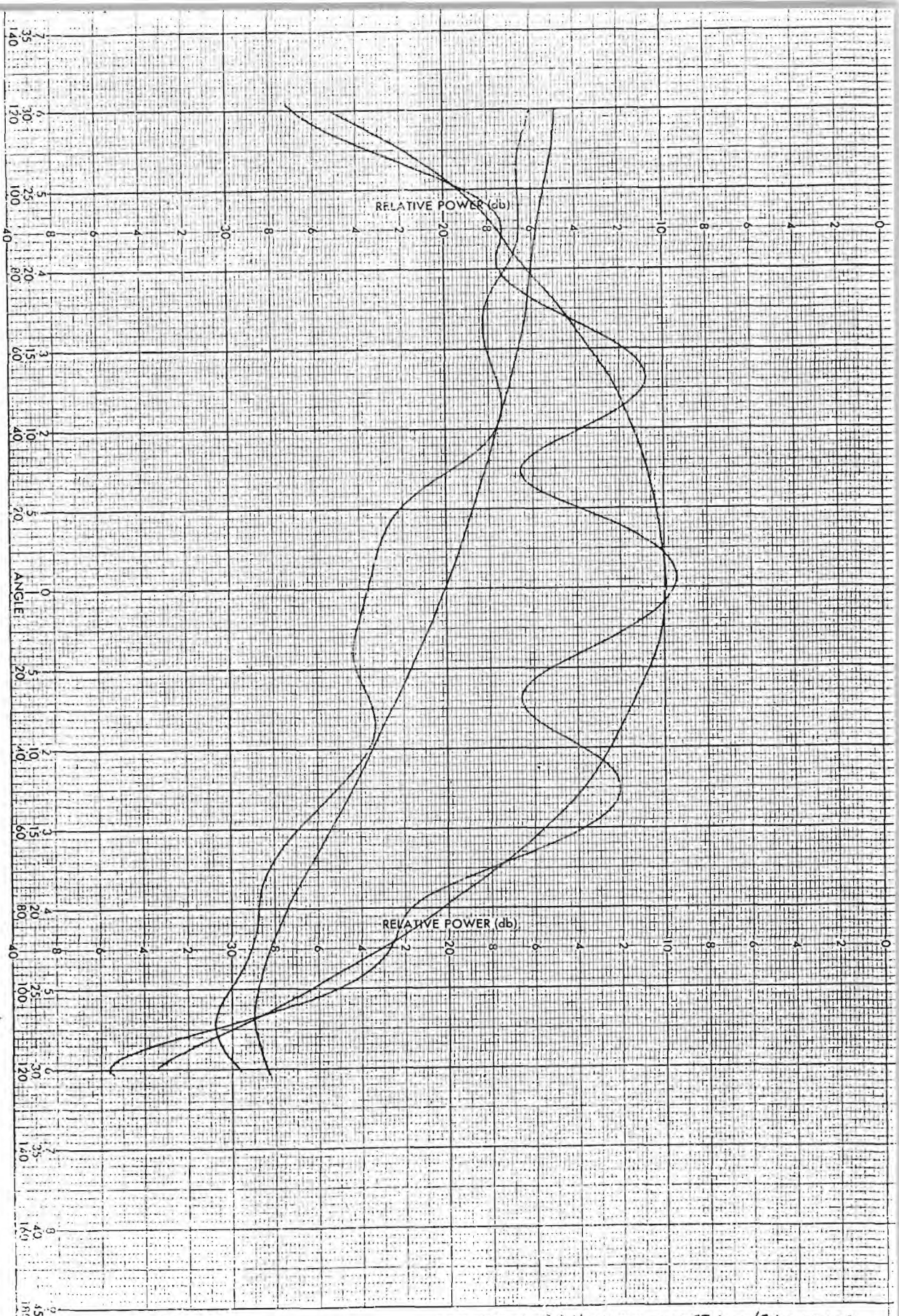
REMARKS F = 2.6 GHZ

VERTICAL POLARIZATION ⊥ TO JOINT PANEL IIB LAP JOINT

HORN PROBE TO JOINT DIST. = 3.5" @ NORMAL INCID.

BLUE = FREE SPACE
GREEN = NORMAL INCIDENCE
DOTTED GREEN = 20° INCIDENCE ANGLE HORN BETWEEN BOLTS



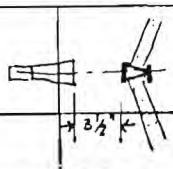


PROJECT A3884 RUN 5
REMARKS F = 2.6 GHz
VERTICAL POLARIZATION ⊥ TO JOINT

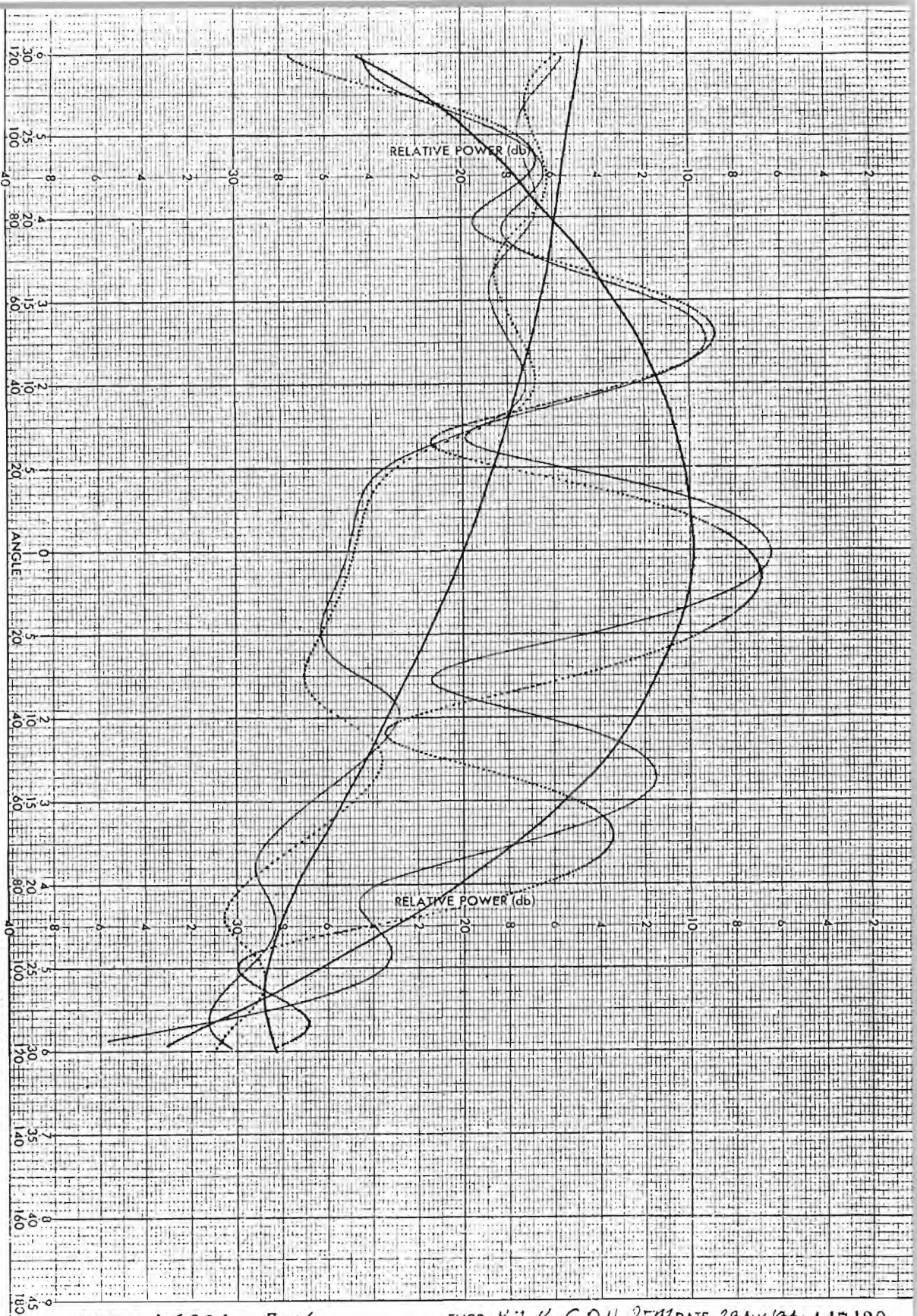
ENGR K. E. GOLDMAN DATE 29 AUG. '84 3:10 PM

PANEL IV4 - TWIN CHANNEL

47419



BLUE = FREE SPACE
GREEN = NORMAL INCIDENCE TO JOINT
(PANELS AT ⊥ TO JOINT)

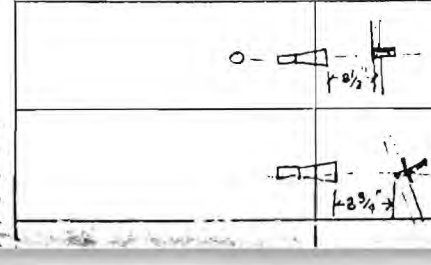


PROJECT A 3804 RUN 6

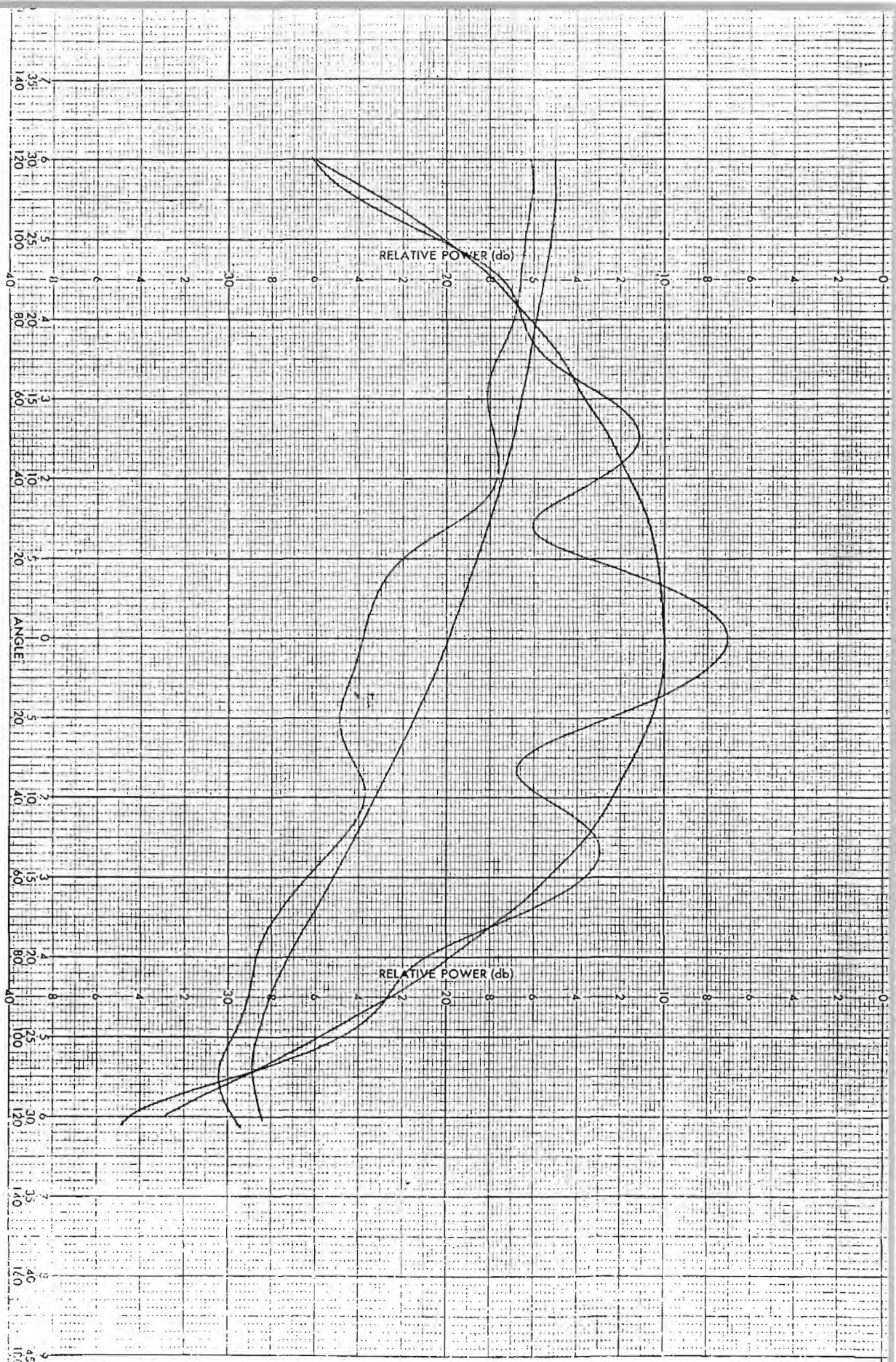
REMARKS F = 2.6 G-2

ENGR KJB GDH, PTM DATE 29 AUG '84 3:25 PM 147120

VERTICAL POLARIZATION ⊥ TO JOINT PANEL III A (1" THICK FLANGE JOINT)

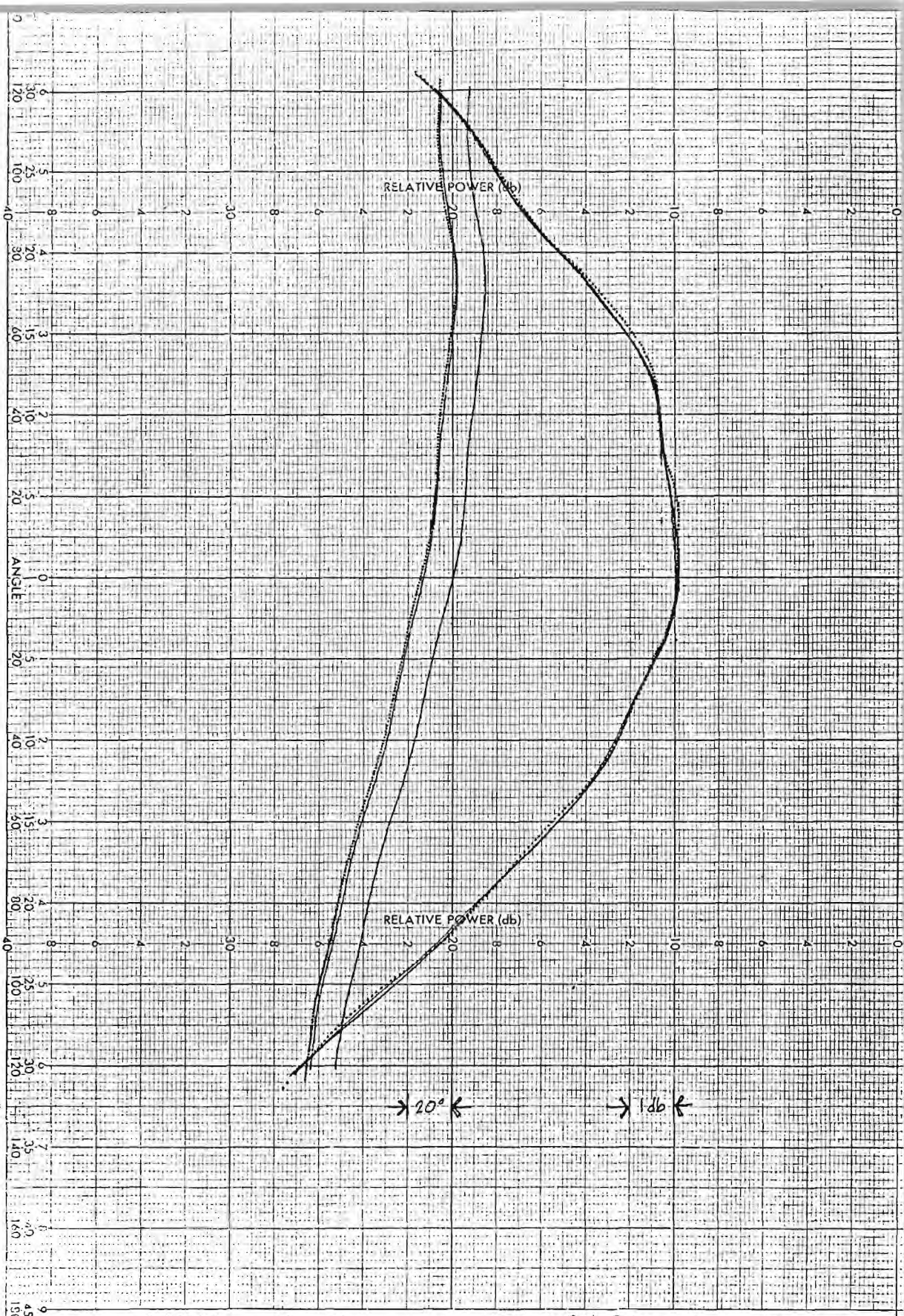


BLUE = FREE SPACE
GREEN = NORMAL INCIDENCE
NO BOLT @ CENTER
DOTTED GREEN = 20° INCIDENCE ANGLE



PROJECT 13884 RUN NO 7 ENGR KJB GCH PFM DATE 29 AUG. '84 147421
REMARKS 2.6 GHz
VERTICAL POLARIZATION ⊥ TO JOINT
PANEL IV B CHANNEL-FLANGE JOINT

BLUE = FREE SPACE
GREEN = NORMAL INCIDENCE



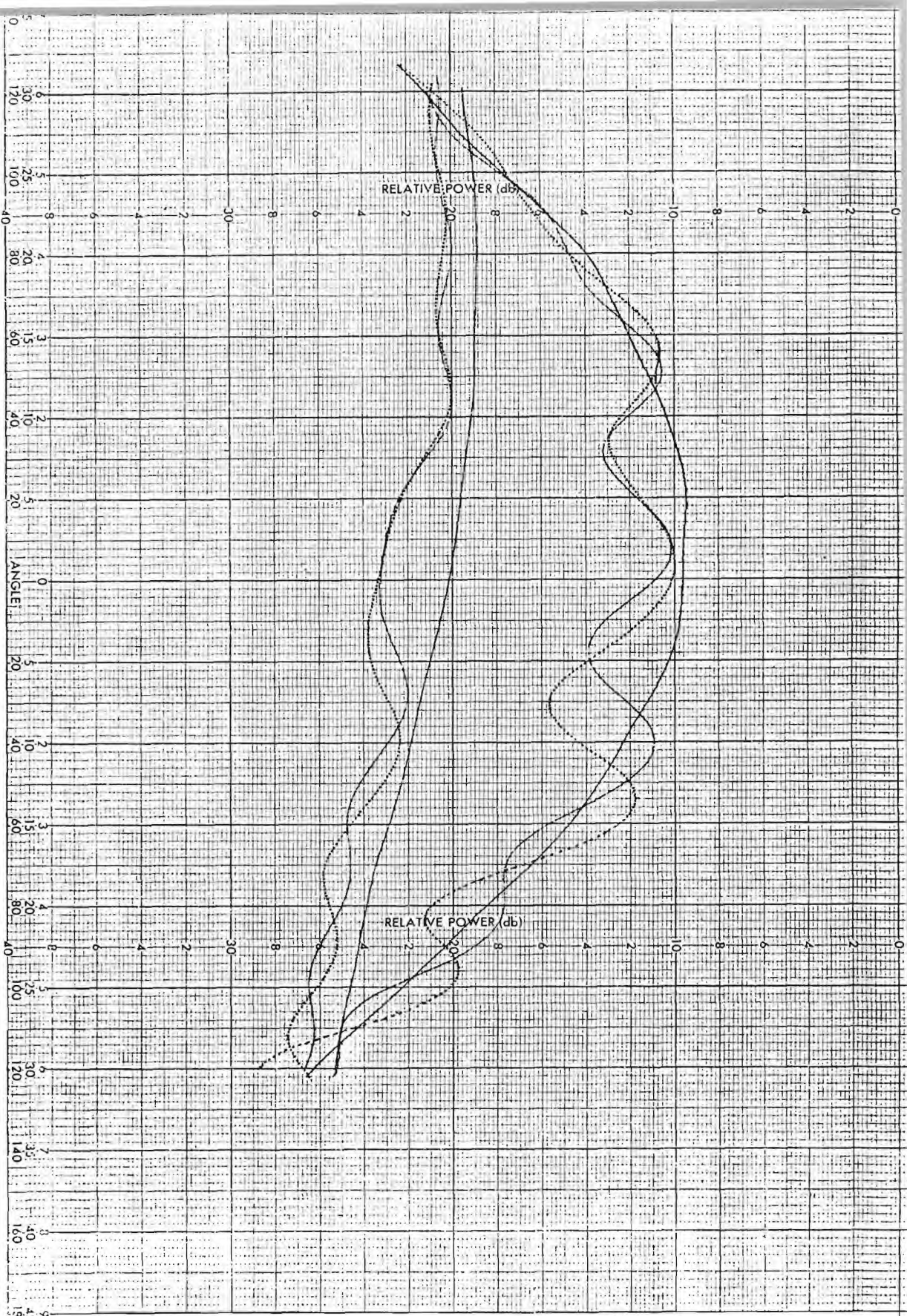
PROJECT 13884 RUN 8 ENGR [illegible] DATE 30 AUG 84 147425
REMARKS 2.6 GHz 8:35 AM

HORIZONTAL POLARIZATION PANEL I (PLAIN)

BLUE = FREE SPACE
GREEN = NORMAL INCID. PANEL I
DOTTED GREEN = 20° INCID. "

4¼"

DISTANCE FROM SCAN HORN TO NORMAL PANEL 4¼"

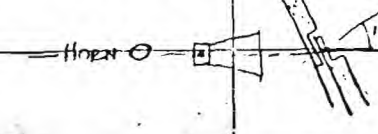


PROJECT A3884 RUN 9 ENGR PJB, GDH, PTM DATE 30 AUG '84 | 47427
9:15 AM

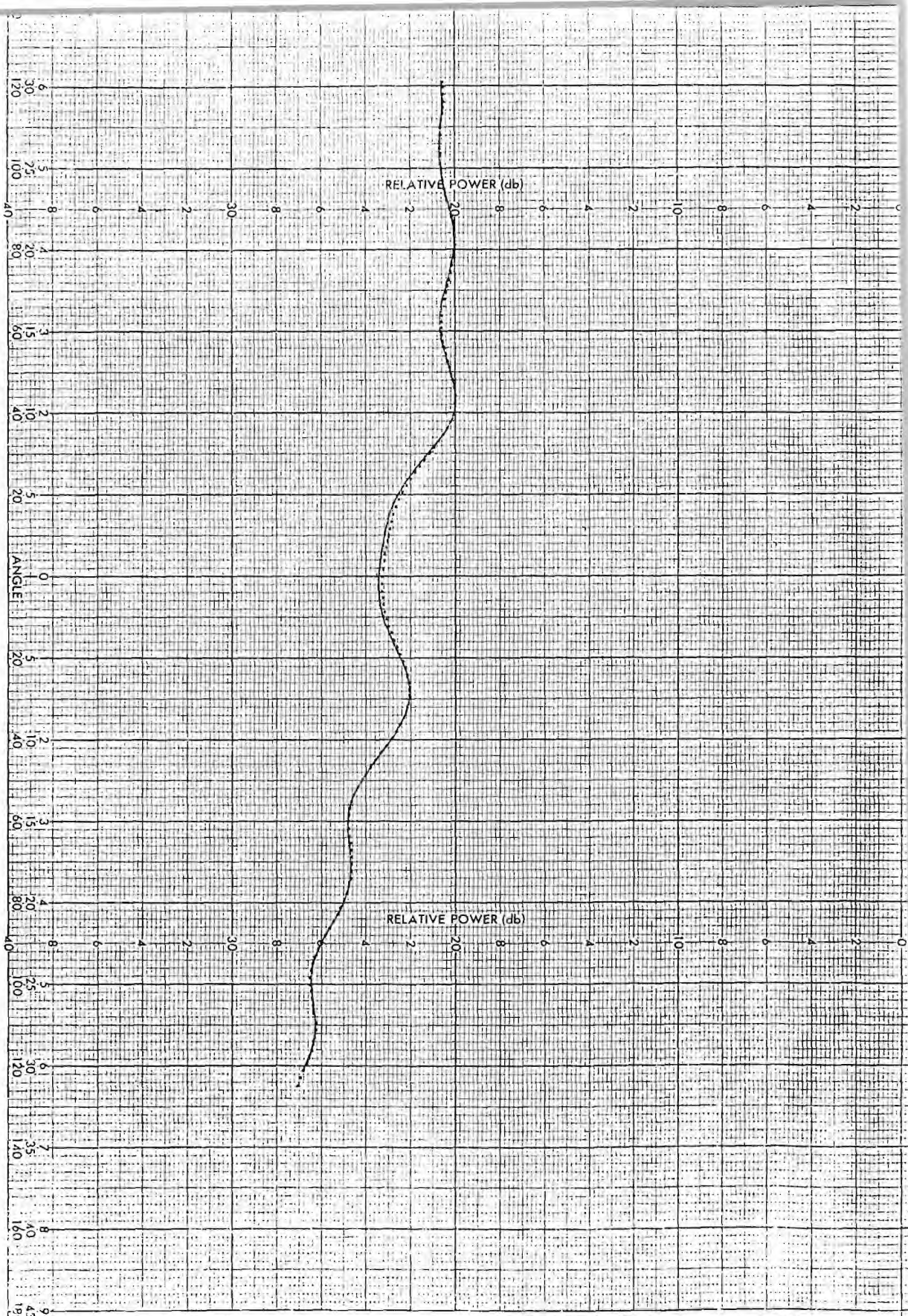
REMARKS 2.6 GHz

HORIZONTAL POLAR. 11 TO JOINT PANEL II B (LAP JOINT)

HORN TO JOINT DIST. = 4½" NORMAL



BLUE = FREE SPACE
GREEN = NORMAL INCID.
DOTTED GREEN = 15° INCID.

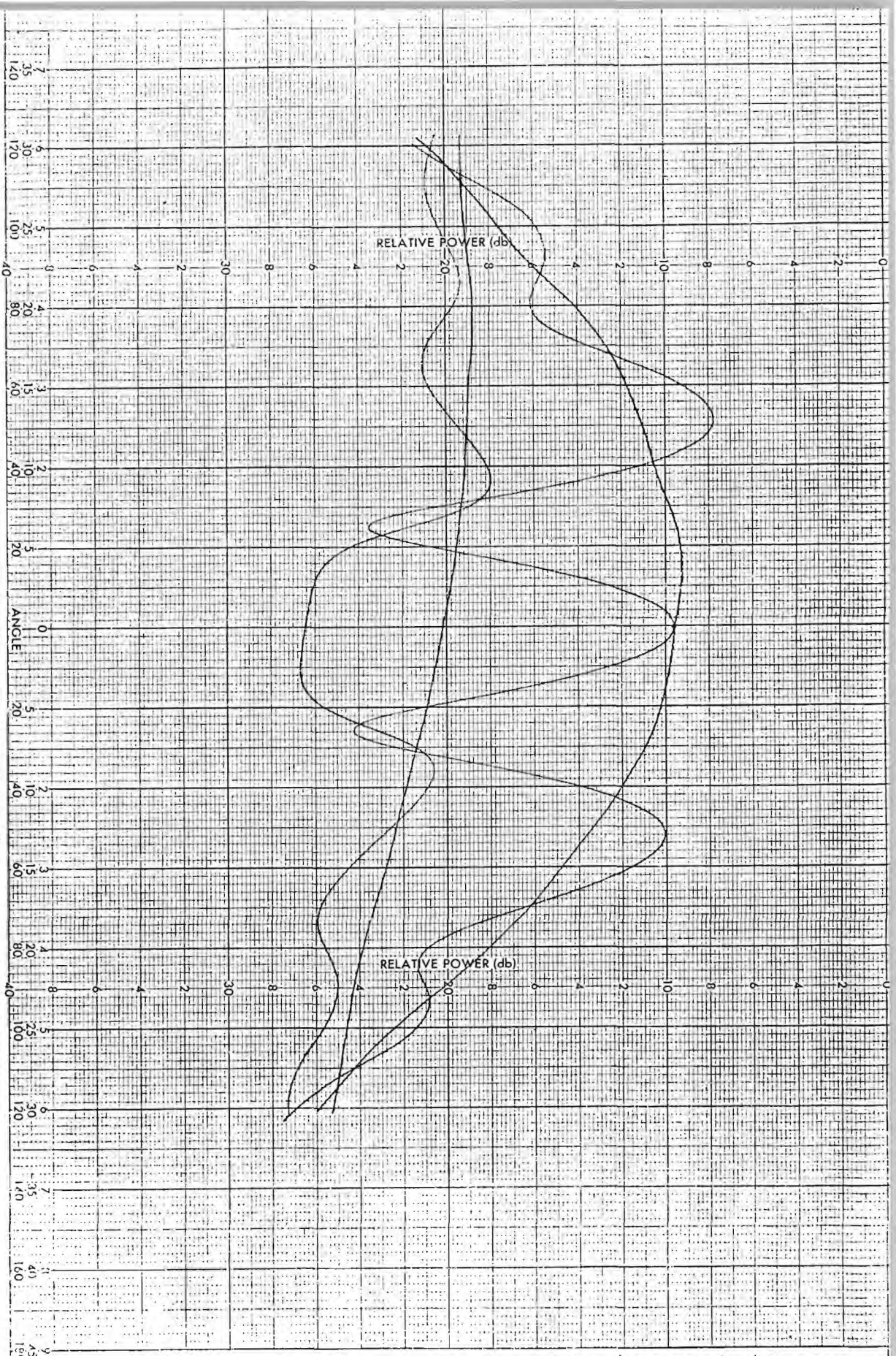


PROJECT A3884 RUN 9A ENGR RJE, GDH, PTM DATE 8-10 84 17426
REMARKS E to E-2 9:15 AM

PLANE: IIE

HORIZ	INCID.	SOLID = BOLT ON HORN C DOTTED = HORN MIDWAY BETWEEN BOLTS

EFFECT OF BOLT

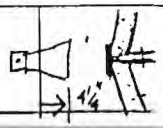


PROJECT A3884 RUN 10 ENGR [illegible], GDH, PM DATE 30 Aug '84 147428
9:30 AM

REMARKS 2.6 GHz

HORIZONTAL POLARIZATION (// TO JOINT)

PANEL IV B (CHANNEL-FLAN



BLUE = FRGB SPACE
GREEN = NORMAL INCID.

PROJECT A3884 RUN 11 ENGR RJB, SUH, PTM/DATE 30 AUG 84 9:45A 147429

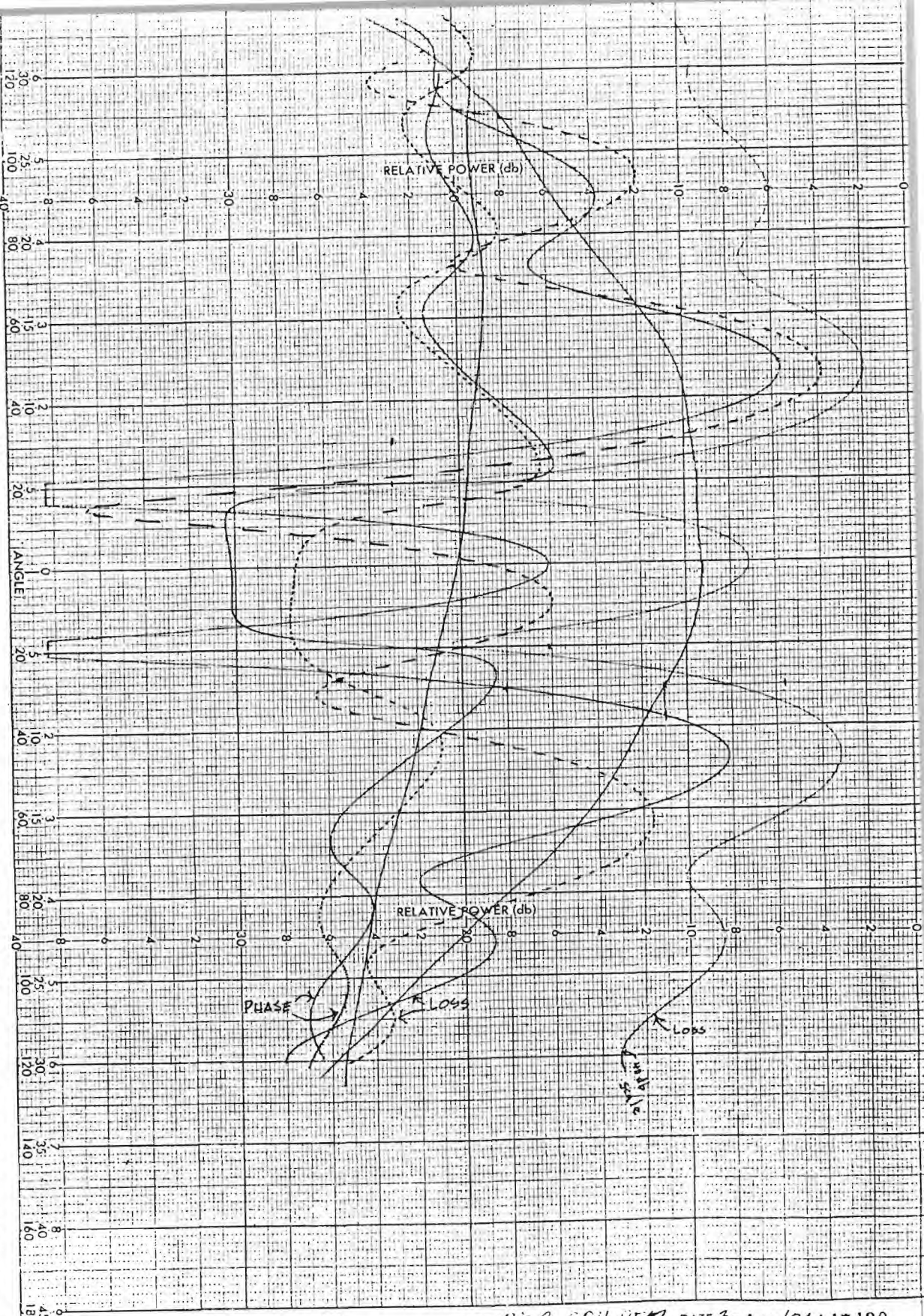
REMARKS 2.6 GHz

HORIZONTAL POLARIZATION (// TO JOINT) PANEL II A LAP JOINT

HORN O

BLUE = FREE SPACE
GREEN = NORMAL INCID.
DOTTED GREEN = 15° INCID. X

HORN MIDWAY BETWEEN BOLTS



PROJECT A3884 RUN 12 ENGR R.J.B, S.D.Y. P.F.M DATE 30 AUG '84 147430

REMARKS FREQ = 2.6 GHz

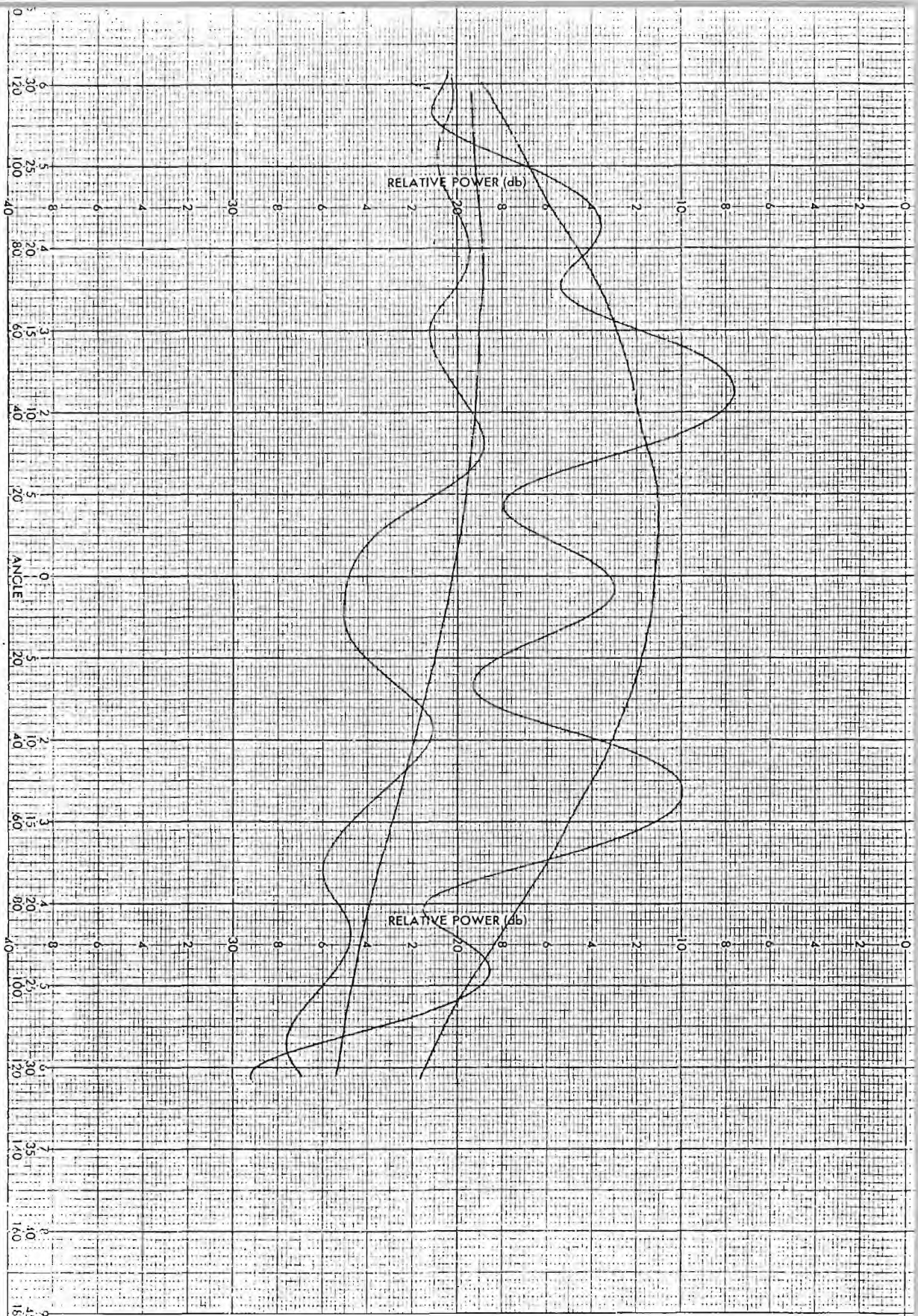
HORIZ. POLARIZATION (// TO JOINT)

PANEL III A FACE FLANGE

HORN ○ — 4¼" — No Box @ ℄

BLUE = FREE SPACE
RED = REDUCE GAIN TO 40db SCALE (INSTEAD OF 20db)
@ NORMAL INCIDENCE (NOTE: 40db IS ACTUAL PRINTED SCALE)

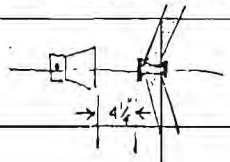
GREEN = NORMAL INCID. ∡
DOTTED GREEN = 20° INCIDENCE ∡



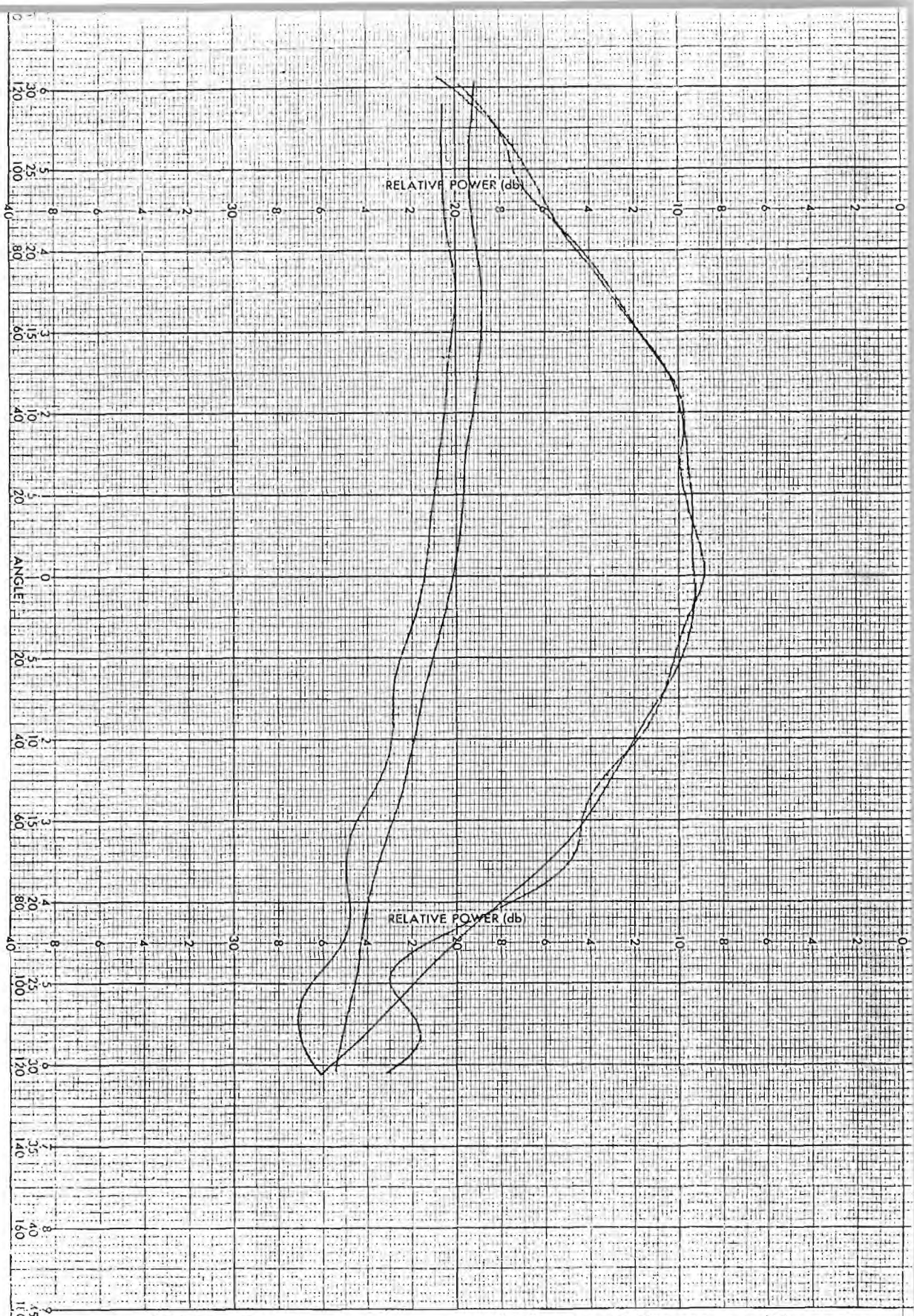
PROJECT A3884 RUN 13
REMARKS 2.6 GHz
HORIZONTAL POLARIZATION (⊥ JOINT)

ENGR R J E, G D H, P F M DATE 30 AUG '84 10:45 AM 147431

PANEL IV A (TWIN CHANNEL)



BLUE = FREE SPACE
GREEN = NORMAL INCIDENCE TO JOINT



PROJECT 3884 RUN 14 ENGR NJB, GDH, HTM DATE 30 Aug '84 11 AM 147433

REMARKS 2.6 GHz

HORIZ. POLARIZATION (11 JOINT) PANEL III B (BUTT JOINT)

HORN

4½"

BLUE = FREE SPACE

GREEN = "NORMAL" INCIDENCE

RELATIVE POWER (db)

ANGLE

RELATIVE POWER (db)

→ 20° ←

→ 1 db ←

PROJECT A3884 RUN 14

REMARKS 2.1 GHz

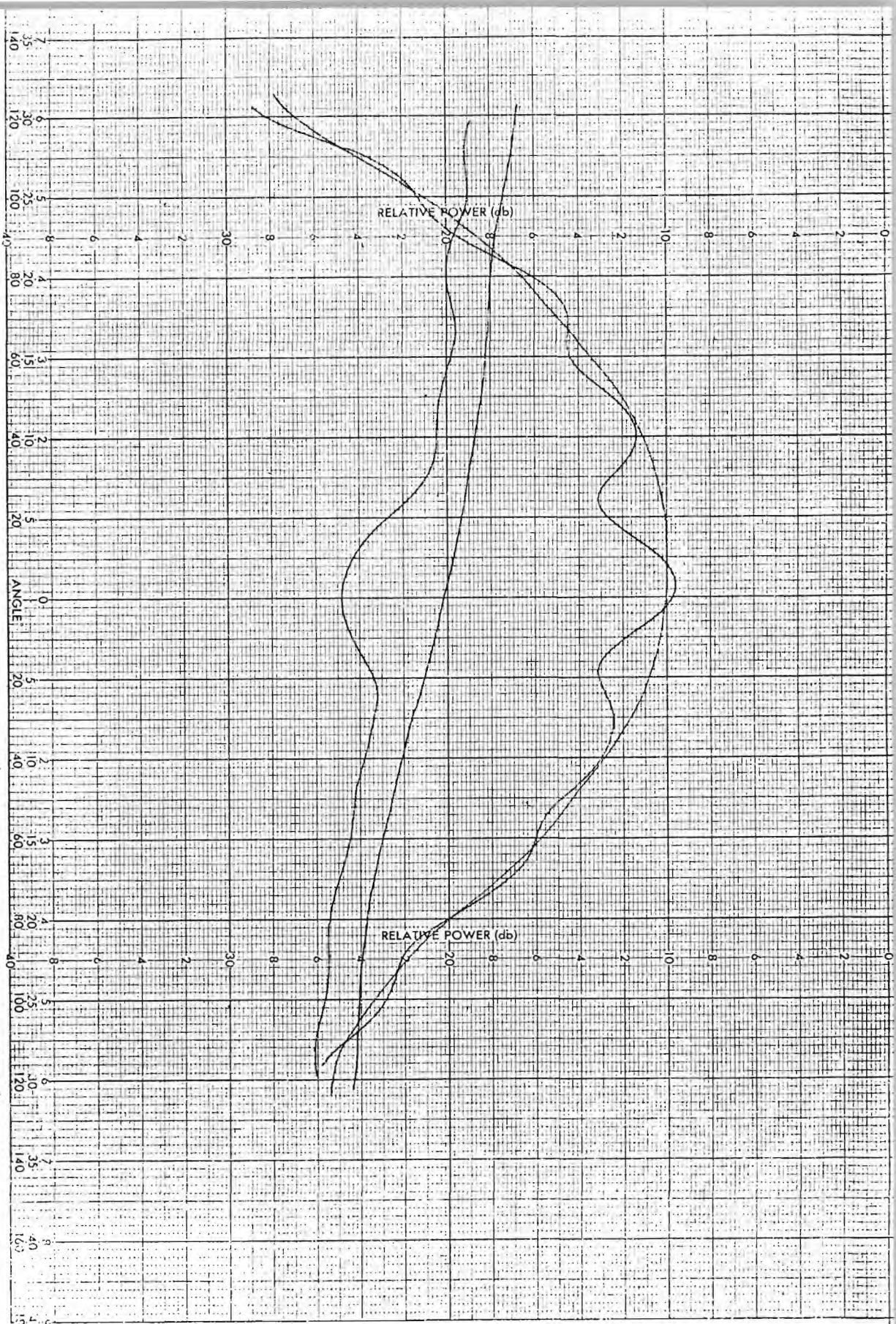
HORIZ POLAR. ⊥ TO JOINT

ENGR PJE, GDH, PTM DATE 30 AUG '84 | 47434 11:15 AM

PANEL IA LAP JOINT

BLUE = FREE SPACE

GREEN = NORMAL INCIDENCE

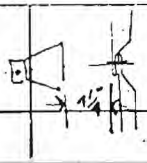


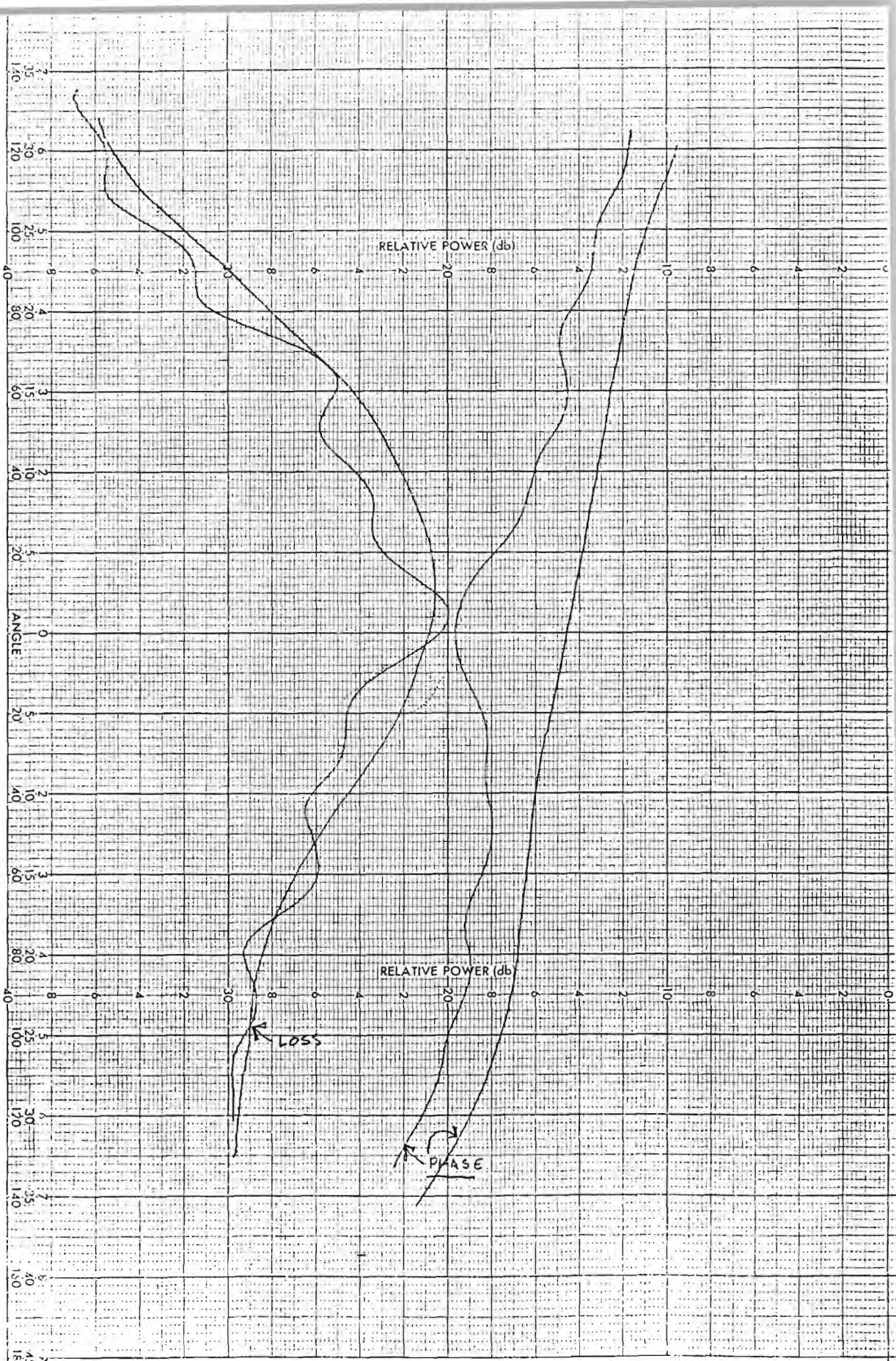
PROJECT A 3884 RUN 15 ENGR RTR, GDH, PTM DATE 30 AUG '84 11:25 AM 147435

REMARKS 3.1 GHz

HORIZ POLLR. (// TO JOINT) PANEL IIA LAP JOINT

BLUE = FREE SPACE
GREEN = NORMAL INCIDENCE



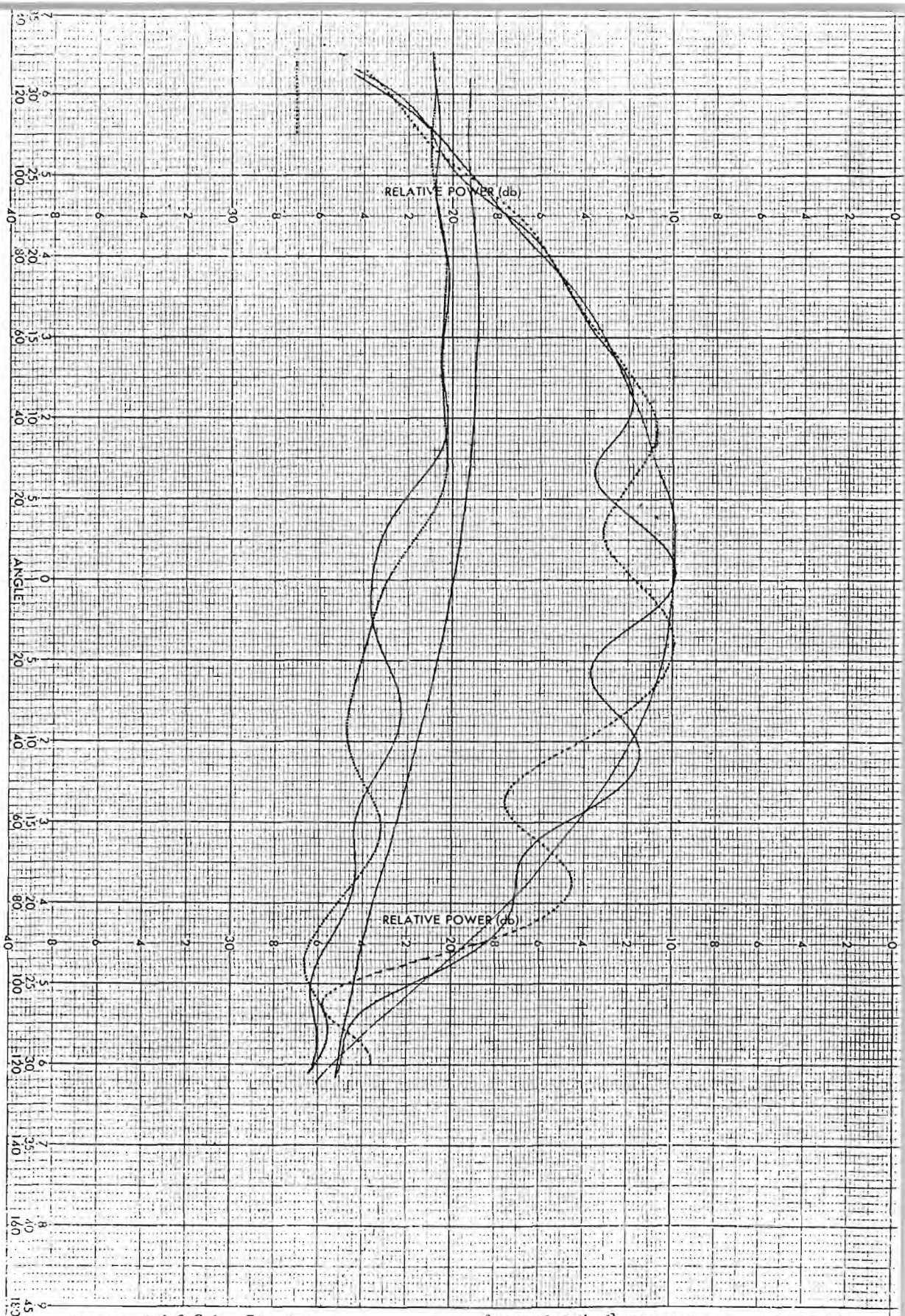


PROJECT A3284 RUN 16 ENGR RJK, GOH, PTH/DATE 30 AUG '64 11:35 AM 47436

REMARKS 3.6 GHz

HORIZ. POLAR. (// TO JOINT) PANEL II A (LAP JOINT)

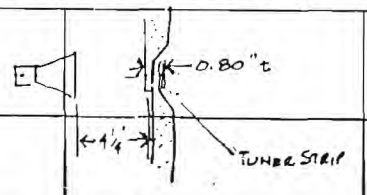
BLUE = FEED SPACE
GREEN = NORMAL INCID.



PROJECT A3884 RUN 17
REMARKS 2.0 GHz
HORIZ. POLAR. (// TO JOINT)

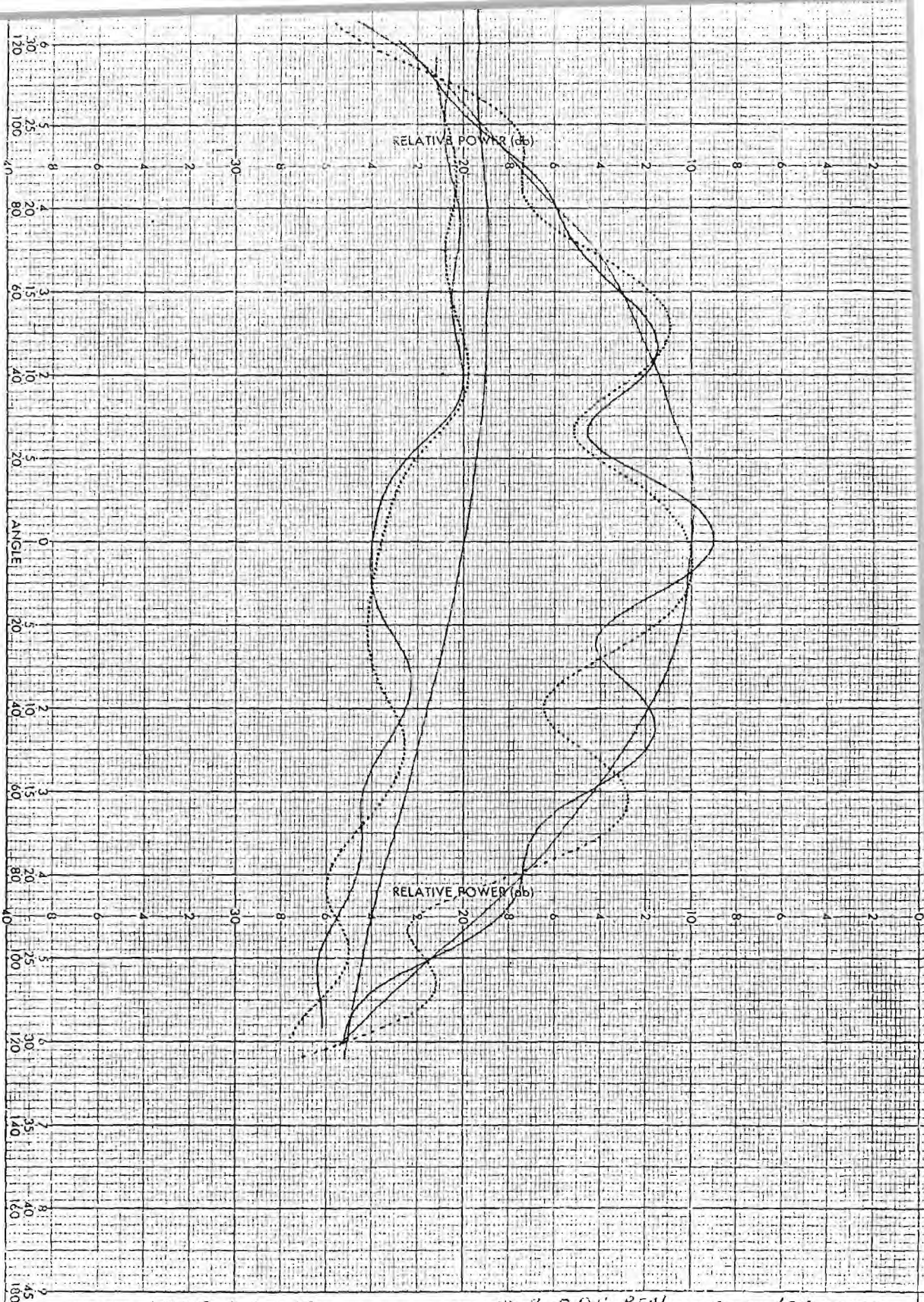
ENGR JJE, GDH, PFM DATE 30 AUG '84 1:20P

PANEL IIA (1) LAP JOINT
W/ 1/8"t ~~TUNER STRIP~~



BLUE = FREE SPACE
GREEN = NORMAL INCIDENCE
DOTTED GREEN = 15° INCID. ⅄

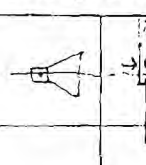
147438



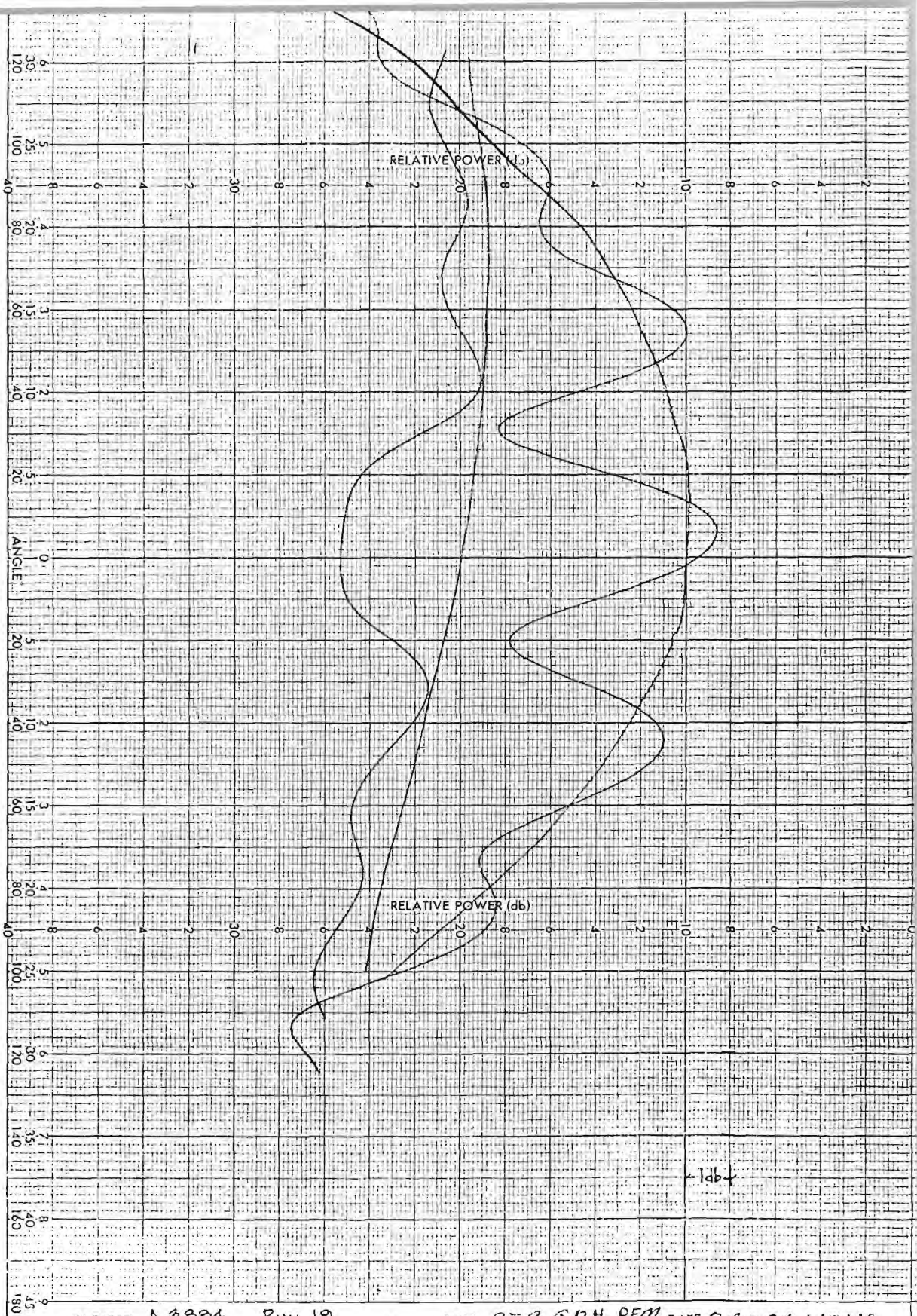
PROJECT A3884 RUN 18
REMARKS 2.6 GHz
HORIZ POLARIZATION (// TO JOINT)

ENGR KJB, GDH, DTM DATE 30 AUG '84 1:30 PM 17437

PANEL 2 LAP JOINT W/ 2 TUNER STRIPS SA 1/8" CRP



BLUE = FREQ SWEEP
GREEN = NORMAL INCID.
DOTTED GREEN = 15° INCID. ∠



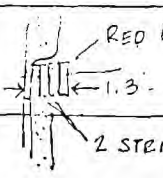
PROJECT A 3884 RUN 19 ENGR RJB, GOH, PFM DATE 8-30-84 1147+10 3:10PM

REMARKS 2.6 GHz

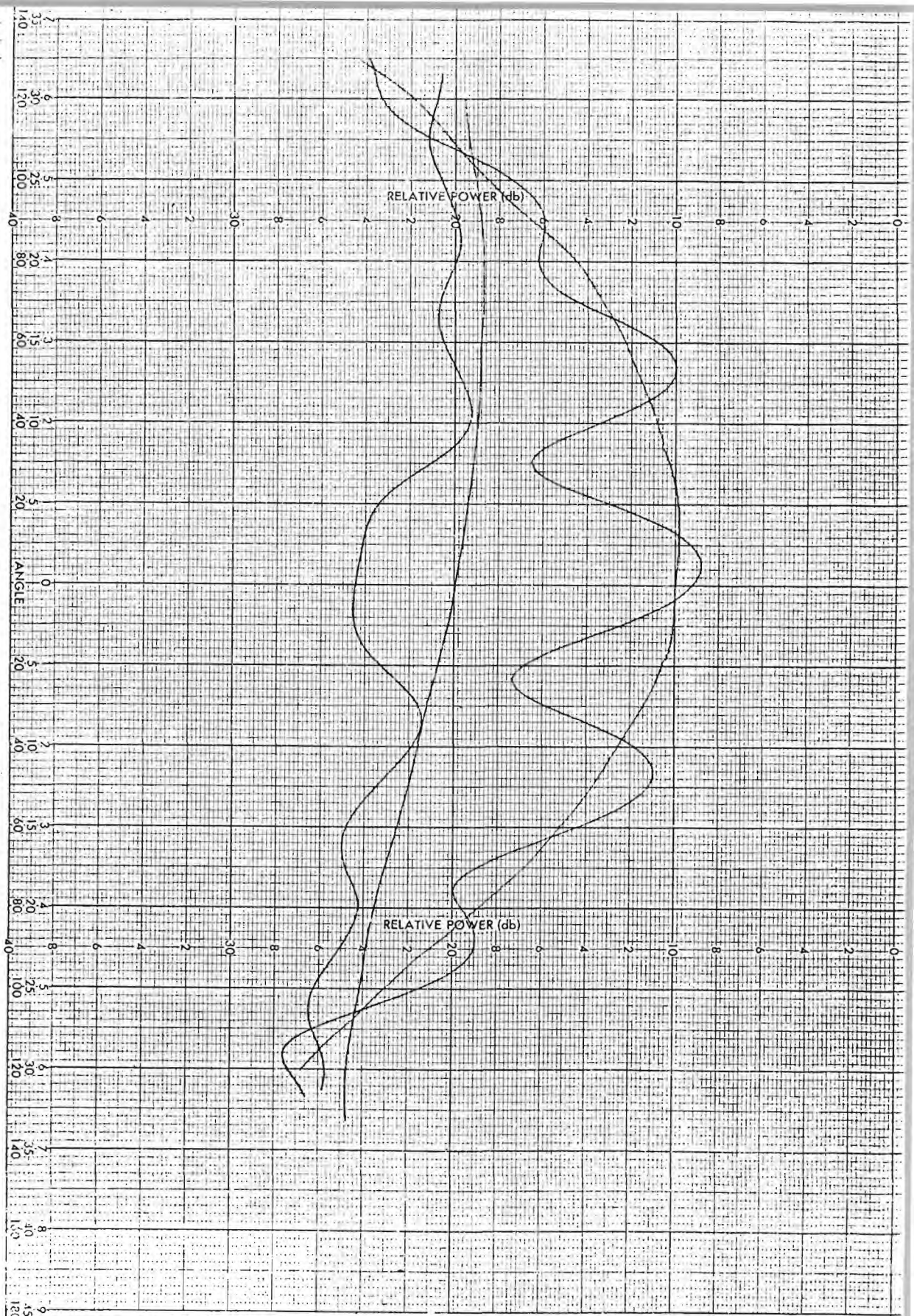
HORIZ. POLAR. (// TO JOINT)

PANEL II A(3) LAP JOINT

W/ 3 UNDER STRIPS



BLUE = FREE SPACE

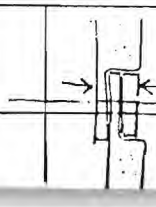


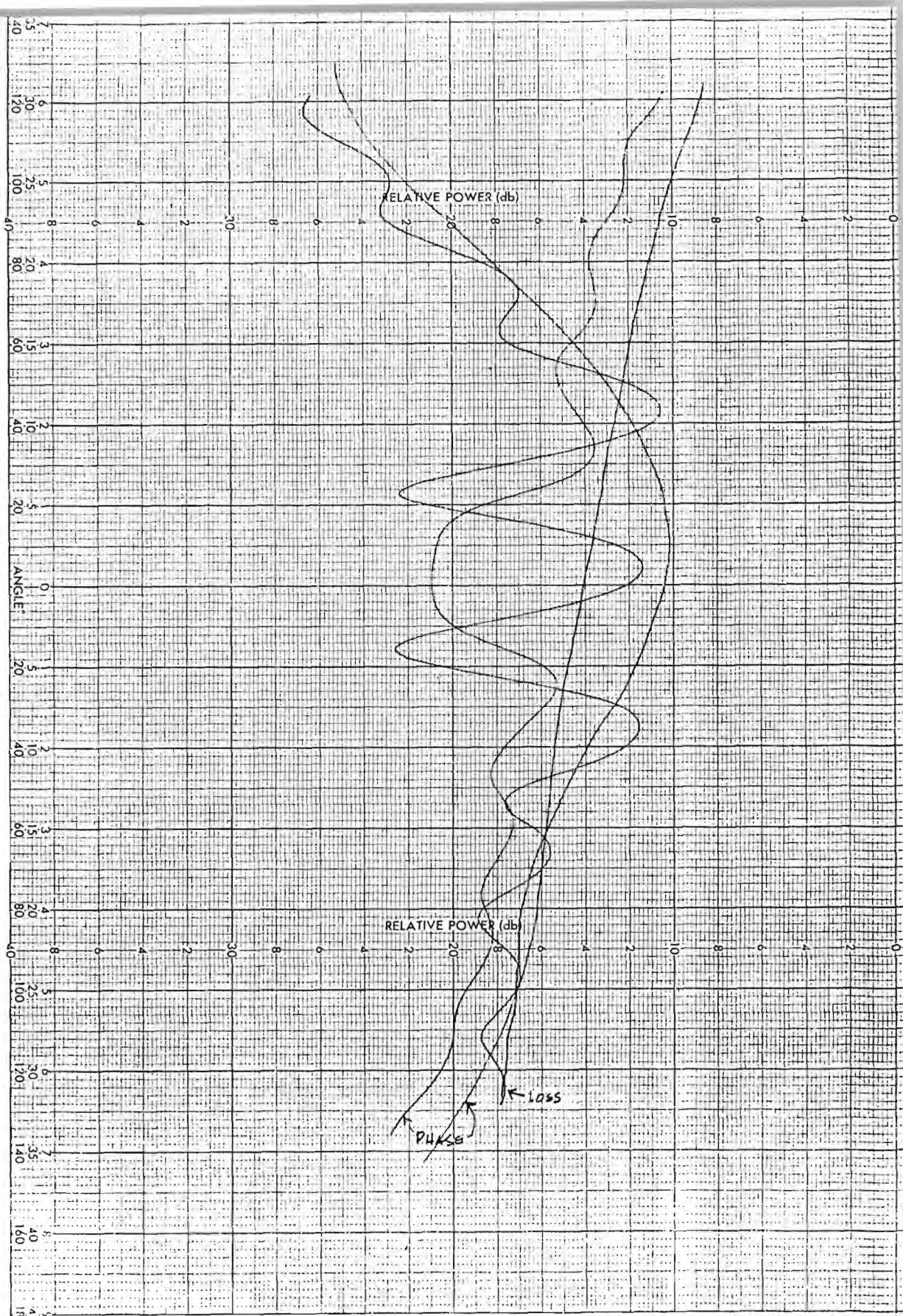
PROJECT 4383A RUN 20
REMARKS 2.6 GHz

ENGR RJE, GDH, FTM DATE 30 AUG '84 17111
3:30 P

HORIZONTAL POLARIZATION (// TO JOINT) PANEL IIB (1) LAP JOINT B WITH 3/8" TUNER STRIP

BLUE = FREE SPACE
GREEN = NORMAL

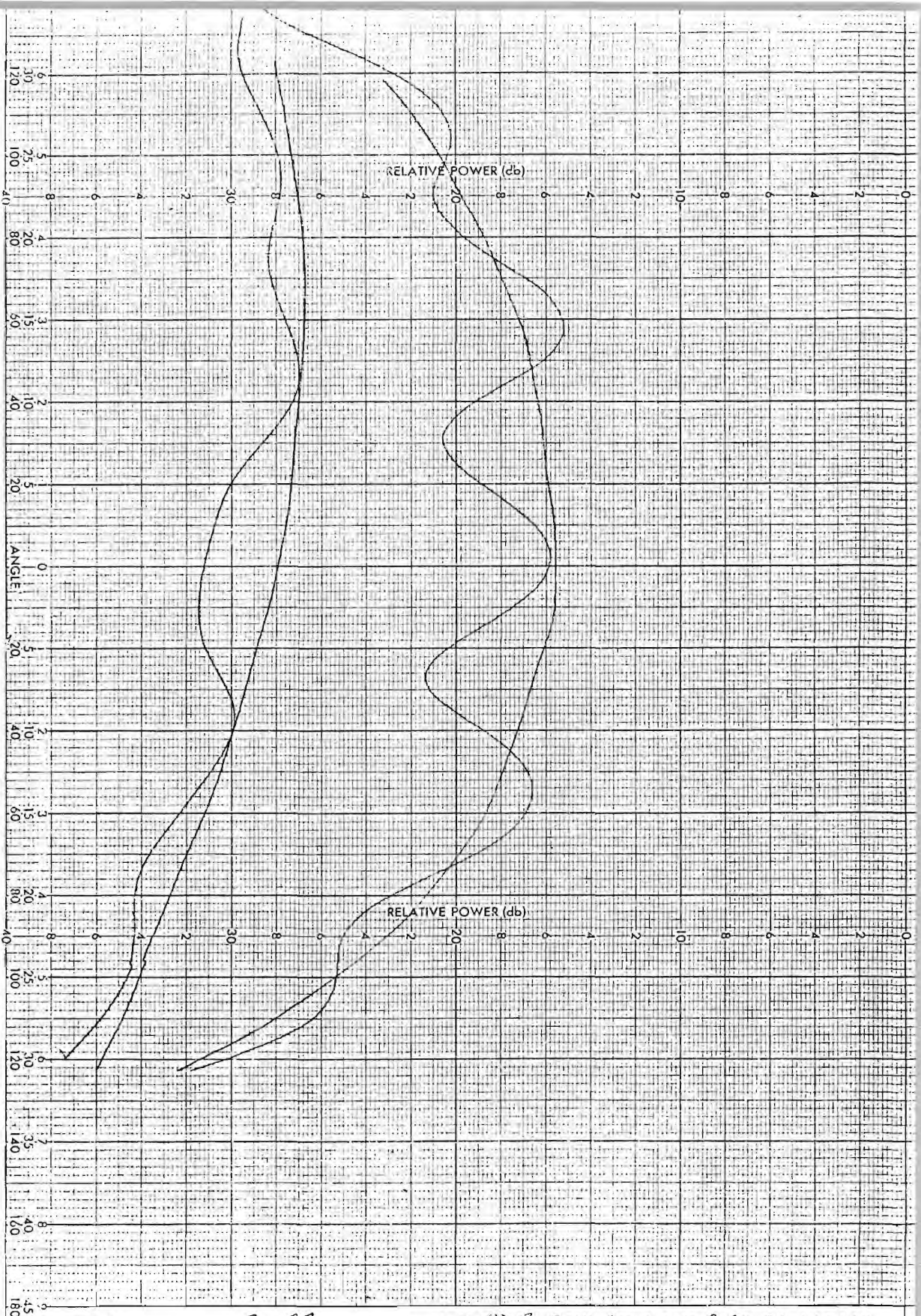




PROJECT A3884 RUN 21 ENGR RJB, GDH, PMM DATE 8.30.84 147112

REMARKS 3.6 GHz,
HORIZ. POLAR. (⊥ TO JOINT) PANEL IIB1 LAP JOINT

		BLUE = FREE SPACE GREEN = NORMAL INC.	w/ 3/8" TUNOL STRIP

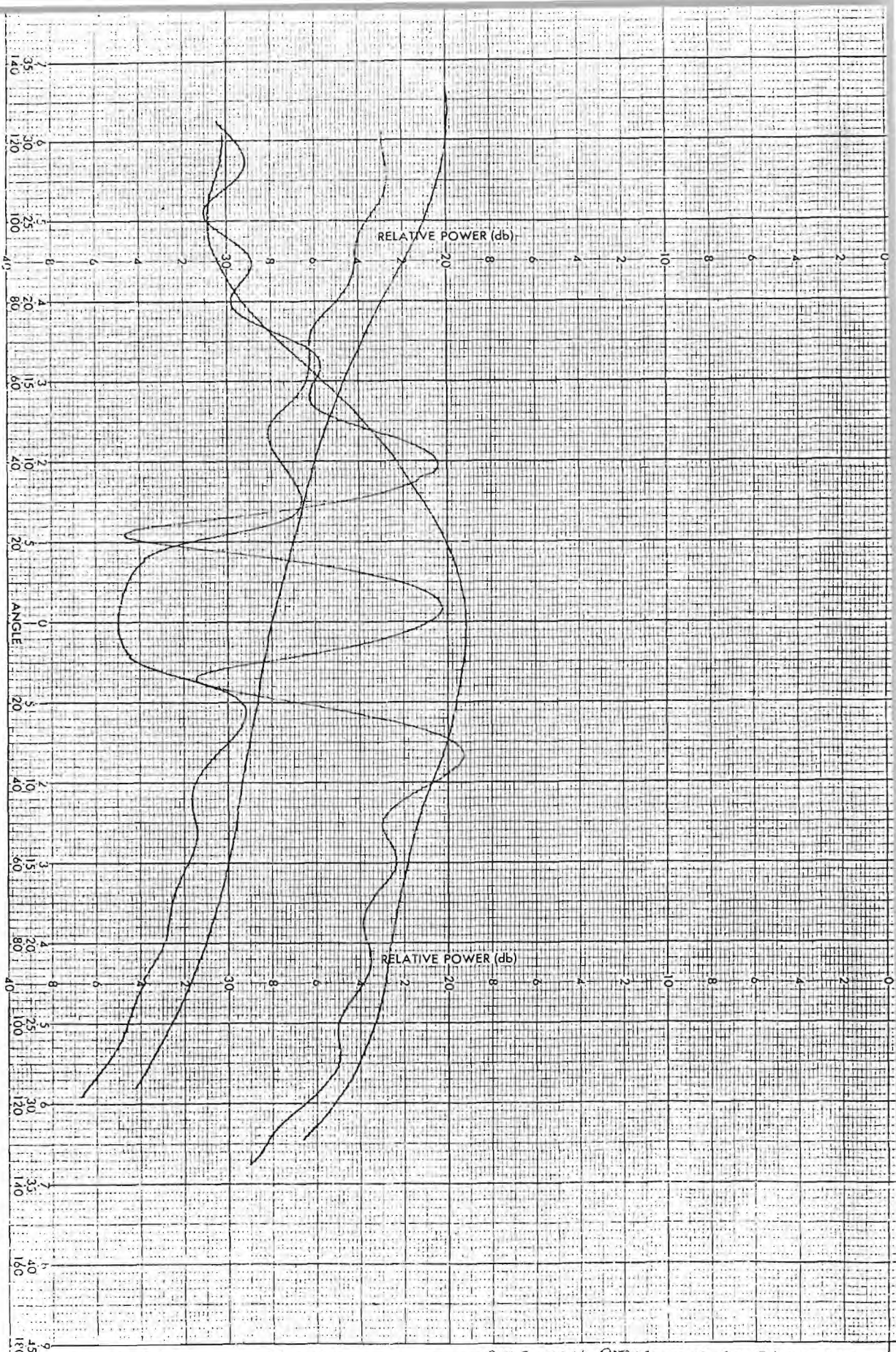


PROJECT RUN 22 ENGR RJC, GDH, PTM DATE 8-30-84 147443

REMARKS 2.1 GHz

HORIZ. POLAR (⊥ TO JOINT) PANEL IIB1 LAP JOINT W/ BIM STRIP

BLUE = FREE SPACE
GREEN = NORMAL INC



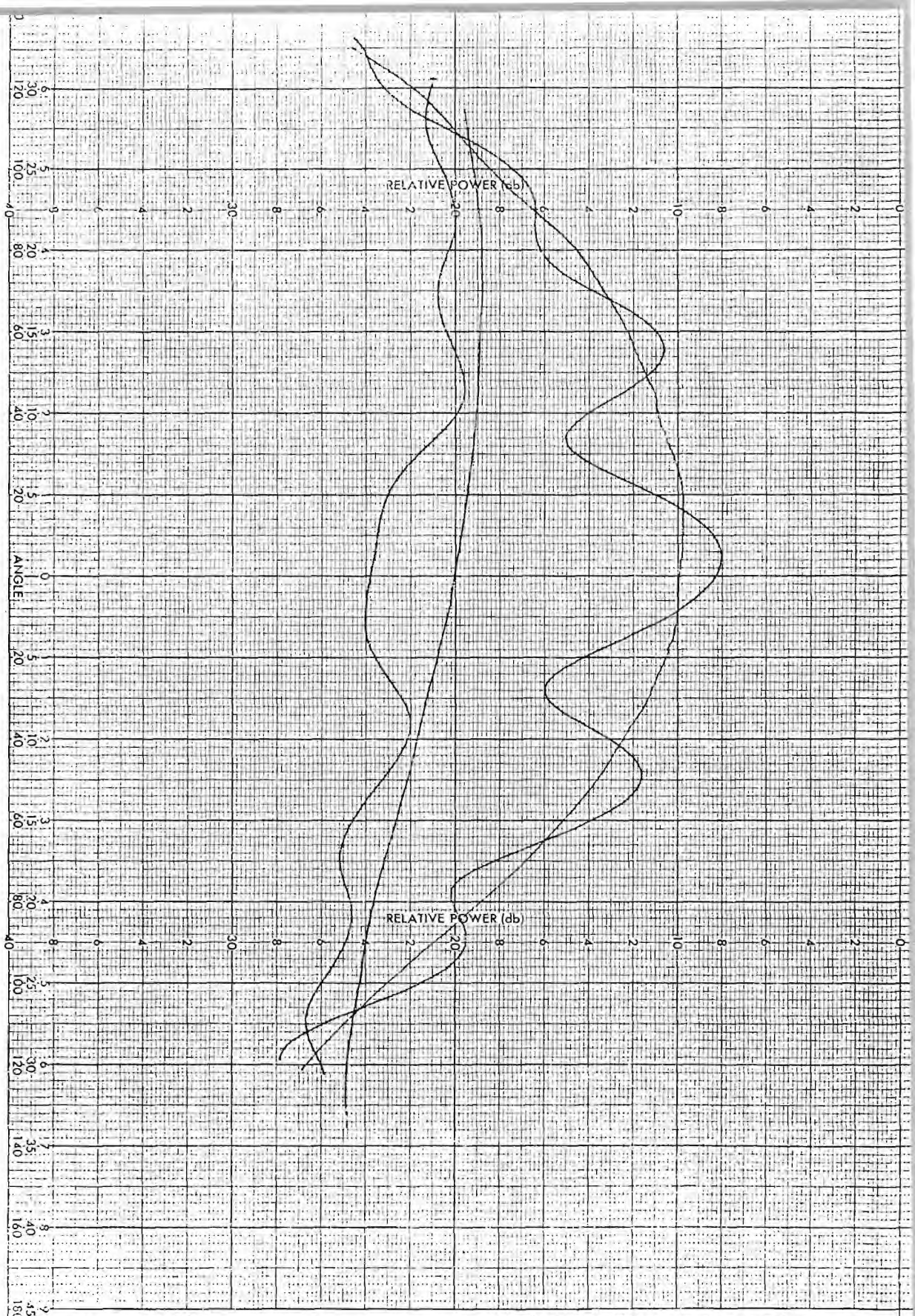
PROJECT A3884 RUN 13 ENGR R.J.B, G.D.H, P.T.M DATE 8·30, 84 1.17 4 PM

REMARKS 4.1 GHz

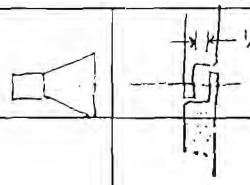
HORIZ POLAR. (// TO JOINT)

PANEL II B 1 LAP JOINT W/ 3/8 STEP TUNER

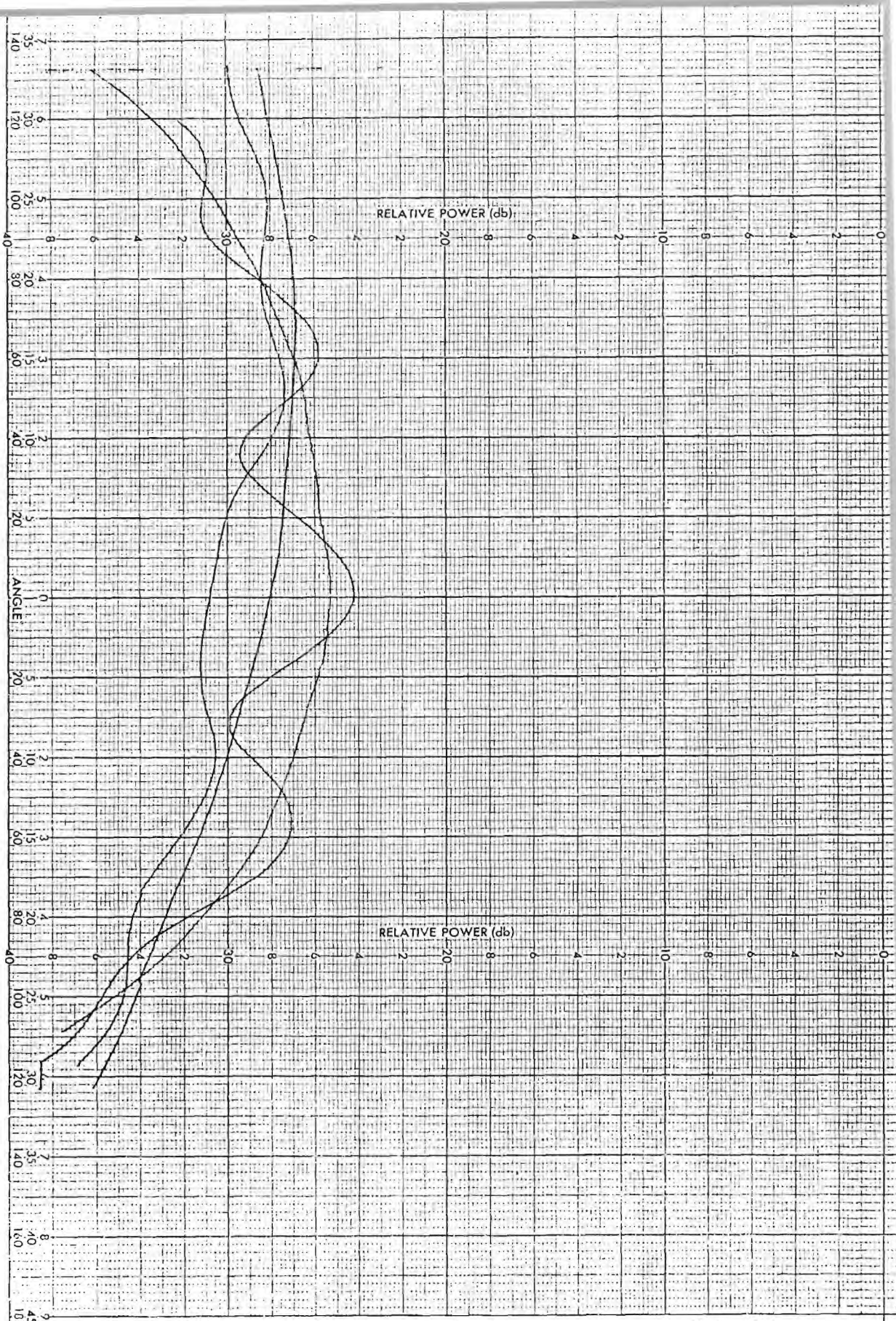
BLUE = FREE SPACE
GREEN = NORMAL



PROJECT A2284 RUN 24 ENGR PJB, GOH, PTM DATE 8·30·84 147445
REMARKS 2.6 GHz 4:40 PM
HORIZ. POLAR. (// TO LAP)
PANEL II B REVERSED LAP



BLUE = FREE SPACE
GREEN = NORMAL INCIDENCE & WITH ½" AIR GAP



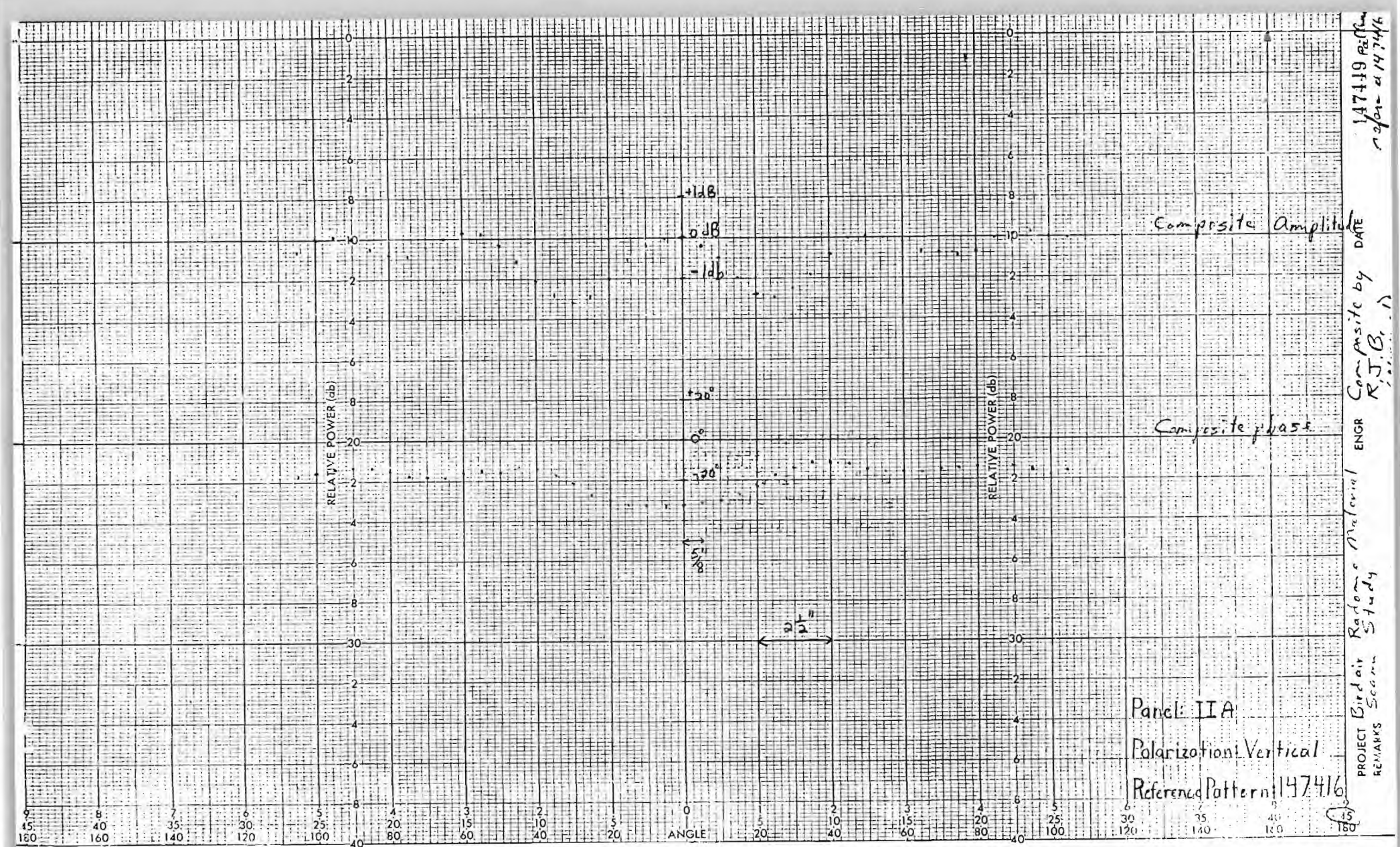
PROJECT A3881A RUN 25 ENGR DATE 8-30-84 / 17116 5:00P

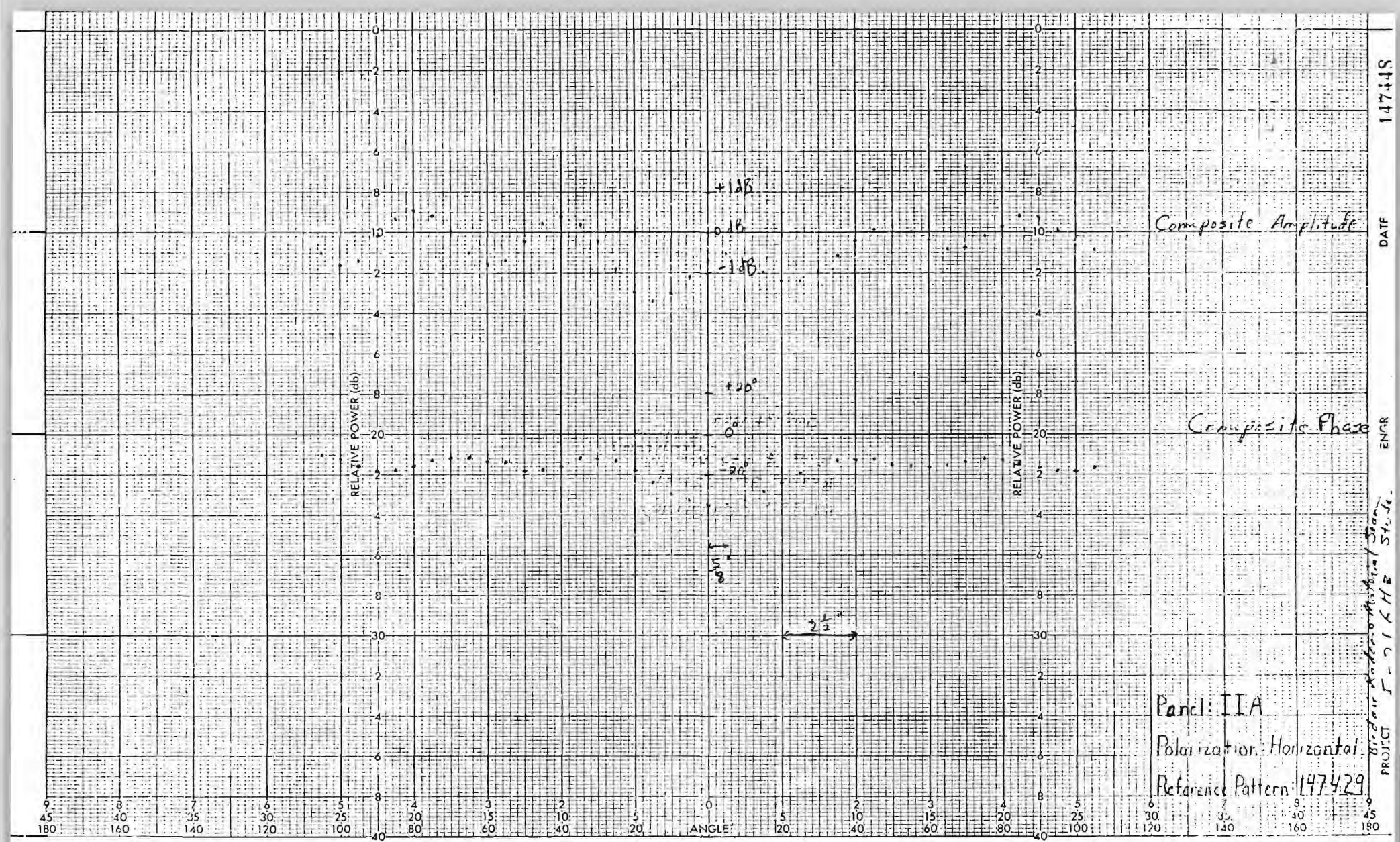
REMARKS 2.1 GHz
HORIZ. POLAR. (// TO JOINT)

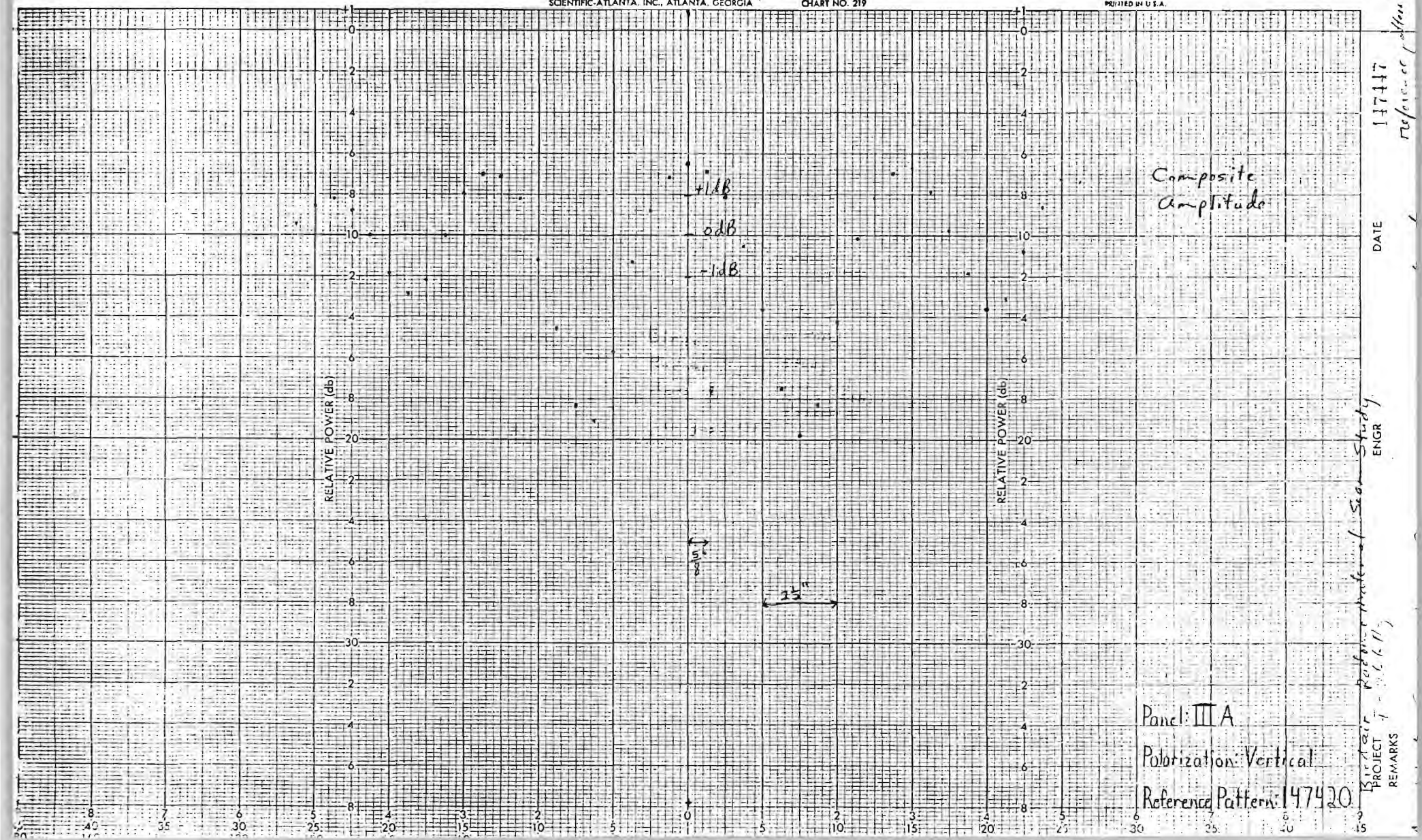
PANEL II B REVERSED LAP ~~WITH 1/2" AIR~~ GAP

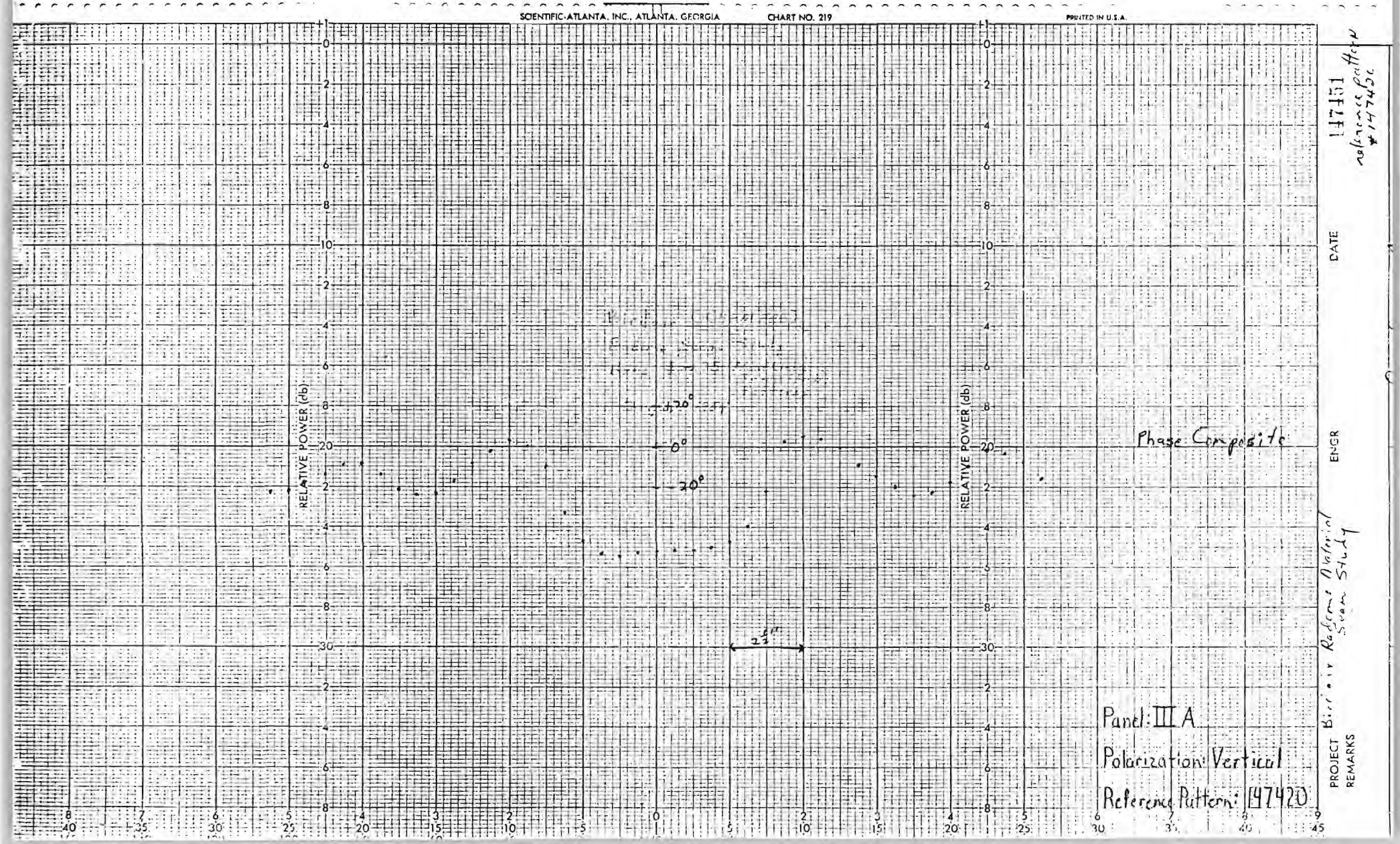
BLUE = FREE SPACE
GREEN = NORMAL INCID. 4

COMPOSITE PLOTS

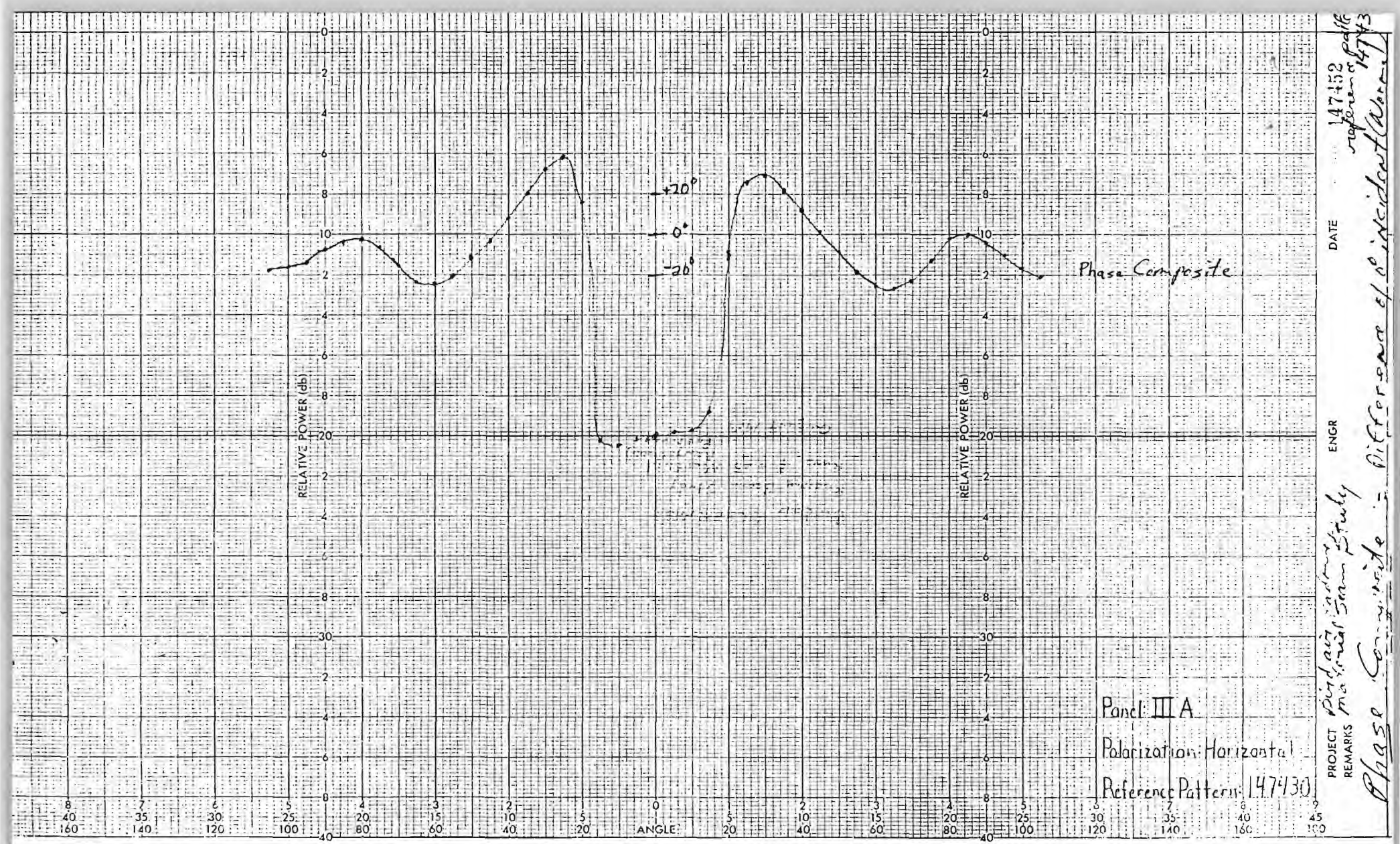

147419 Pattern
Composite Amplitude
Composite phase
+1dB
0dB
-1db
+20°
0°
-20°
5/8"
2 1/2"
RELATIVE POWER (db)
RELATIVE POWER (db)
ANGLE
PROJECT Birdair Radome Material Study
REMARKS Scan
ENGR Composite by R.J.B.
DATE
Panel IIA
Polarization: Vertical
Reference Pattern: 147416

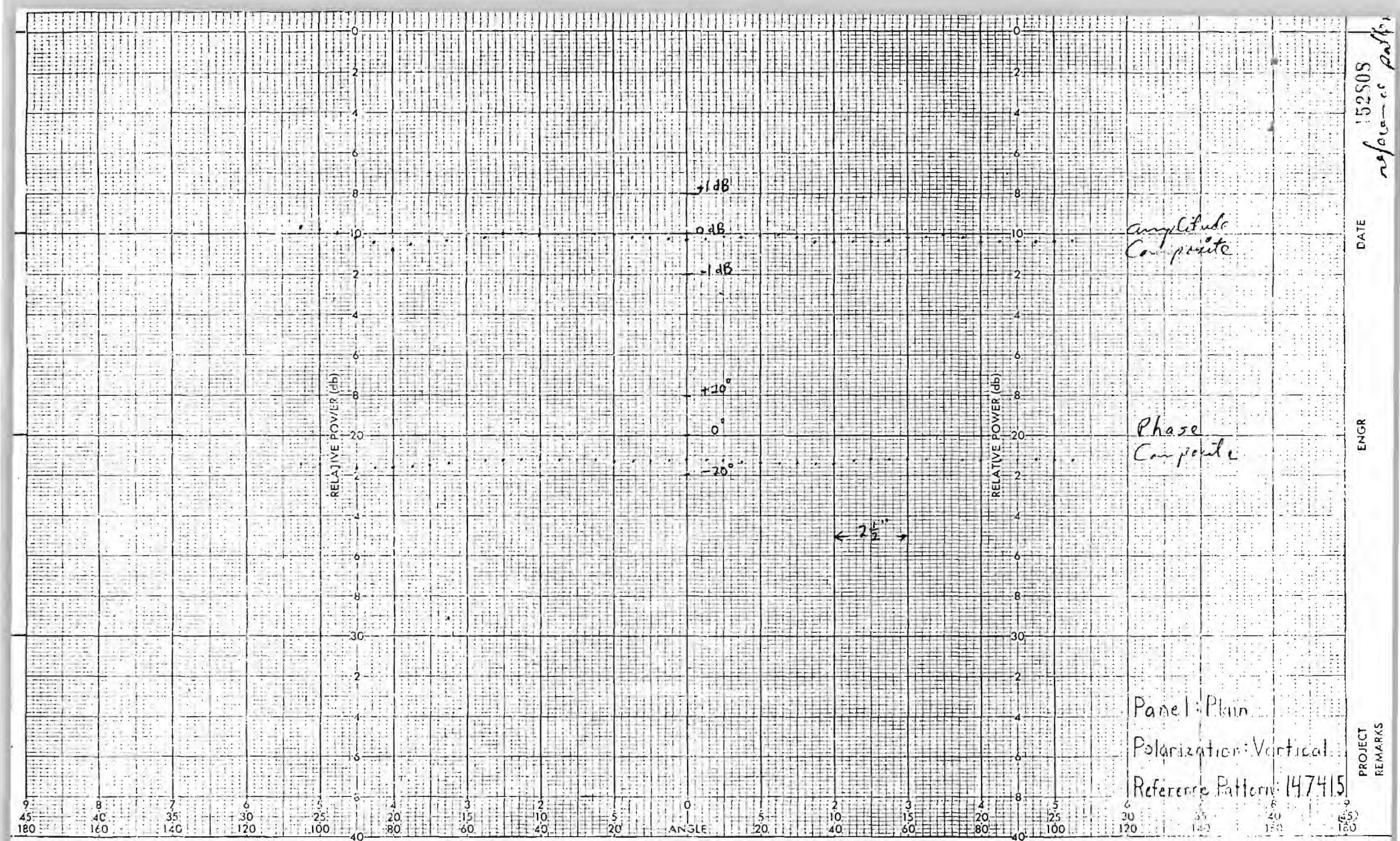

RELATIVE POWER (db)
RELATIVE POWER (db)
ANGLE
+1dB
0dB
-1dB
+20°
0°
-20°
5°
2½°
Composite Amplitude
Composite Phase
Panel: IIA
Polarization: Horizontal
Reference Pattern: 147429
PROJECT
DATE
ENGR
147445

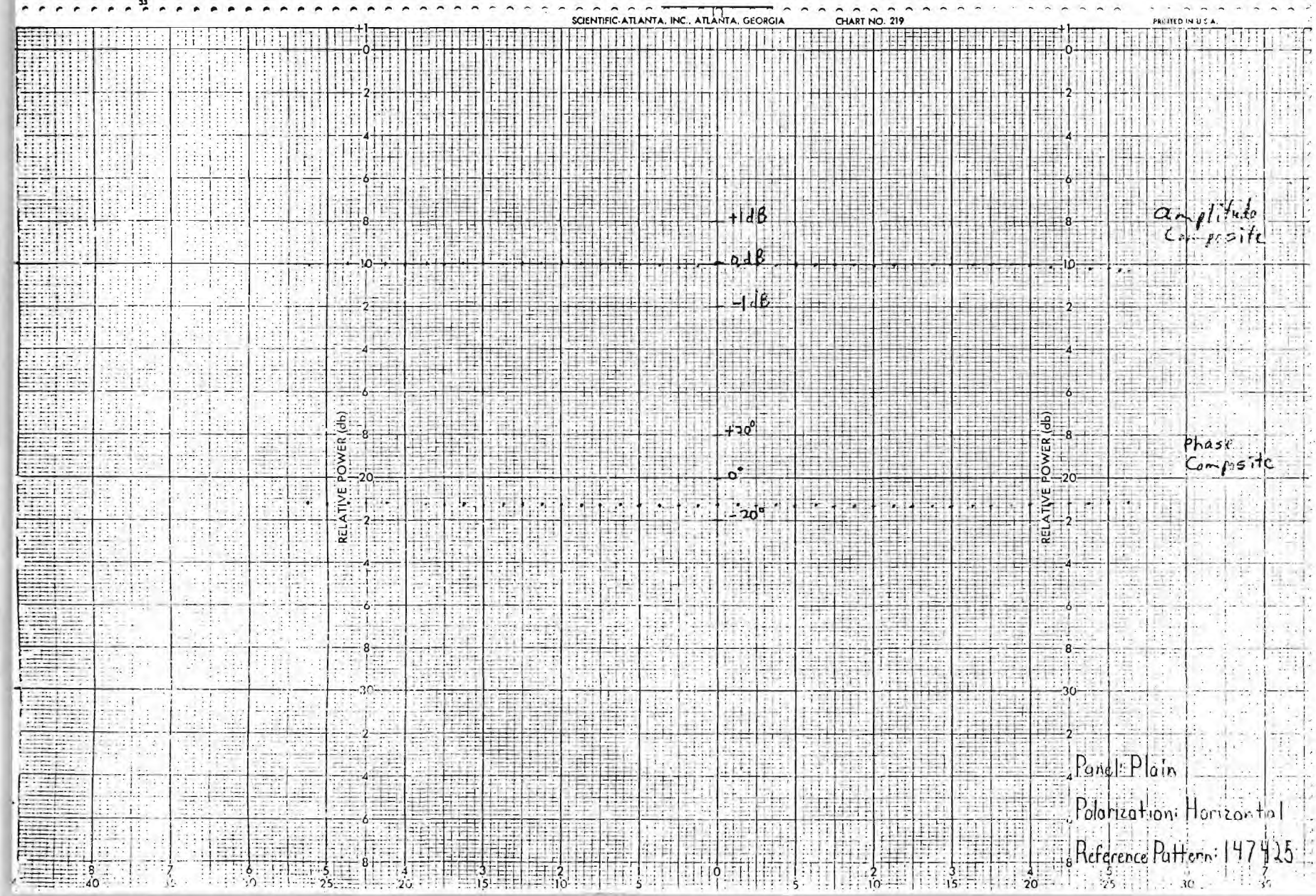

SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA
CHART NO. 219
PRINTED IN U.S.A.
RELATIVE POWER (db)
RELATIVE POWER (db)
+1dB
0dB
-1dB
Composite Amplitude
DATE
ENGR
PROJECT
REMARKS
Panel: III A
Polarization: Vertical
Reference Pattern: 147420


SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA
CHART NO. 219
PRINTED IN U.S.A.
RELATIVE POWER (db)
RELATIVE POWER (db)
+20°
0°
-20°
2½"
Phase Composite
Panel: III A
Polarization: Vertical
Reference Pattern: 147420
147451
reference pattern
DATE
ENGR
PROJECT Bird's Radome Natural Scan Study
REMARKS

RELATIVE POWER (db)
+1dB
0dB
-1dB
Composite Amplitude
Panel: III A
Polarization: Horizontal
Reference Pattern: 147430
RELATIVE POWER (db)
147450
DATE
ENGR
PROJECT
REMARKS
147453


+20°
0°
-20°
Phase Composite
RELATIVE POWER (db)
RELATIVE POWER (db)
ANGLE
Panel III A
Polarization: Horizontal
Reference Pattern: 147430
PROJECT
REMARKS
DATE
ENGR
147452
147453


RELATIVE POWER (db)
RELATIVE POWER (db)
+1 dB
0 dB
-1 dB
+20°
0°
-20°
2½"
ANGLE
amplitude Composite
Phase Composite
Panel: Plain
Polarization: Vertical
Reference Pattern: 147415
DATE
ENGR
PROJECT
REMARKS
152505


SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA
CHART NO. 219
PRINTED IN U.S.A.
RELATIVE POWER (db)
+1dB
0dB
-1dB
+20°
0°
-20°
RELATIVE POWER (db)
Amplitude Composite
Phase Composite
Panel: Plain
Polarization: Horizontal
Reference Pattern: 147425